THE ENGINEER

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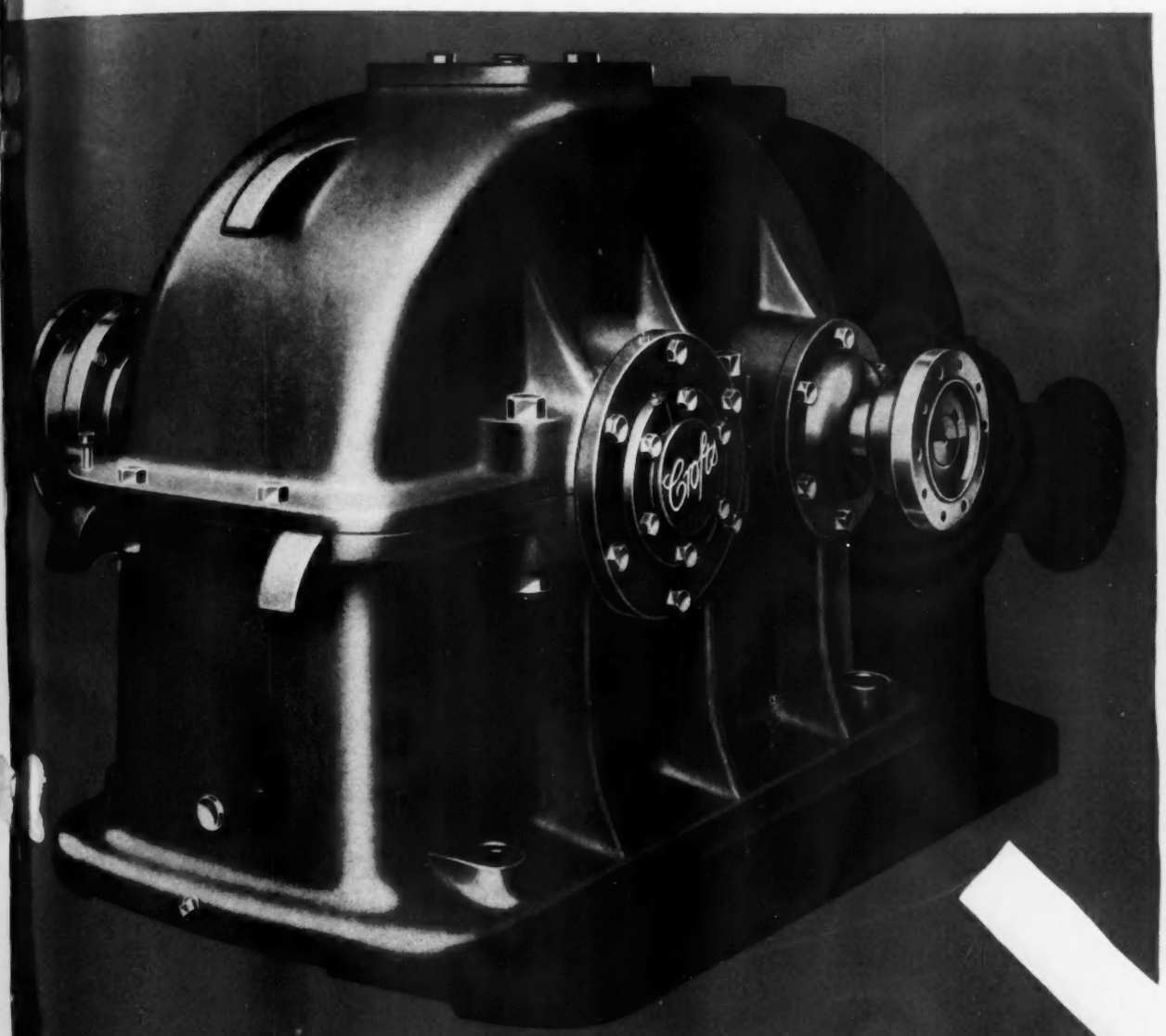

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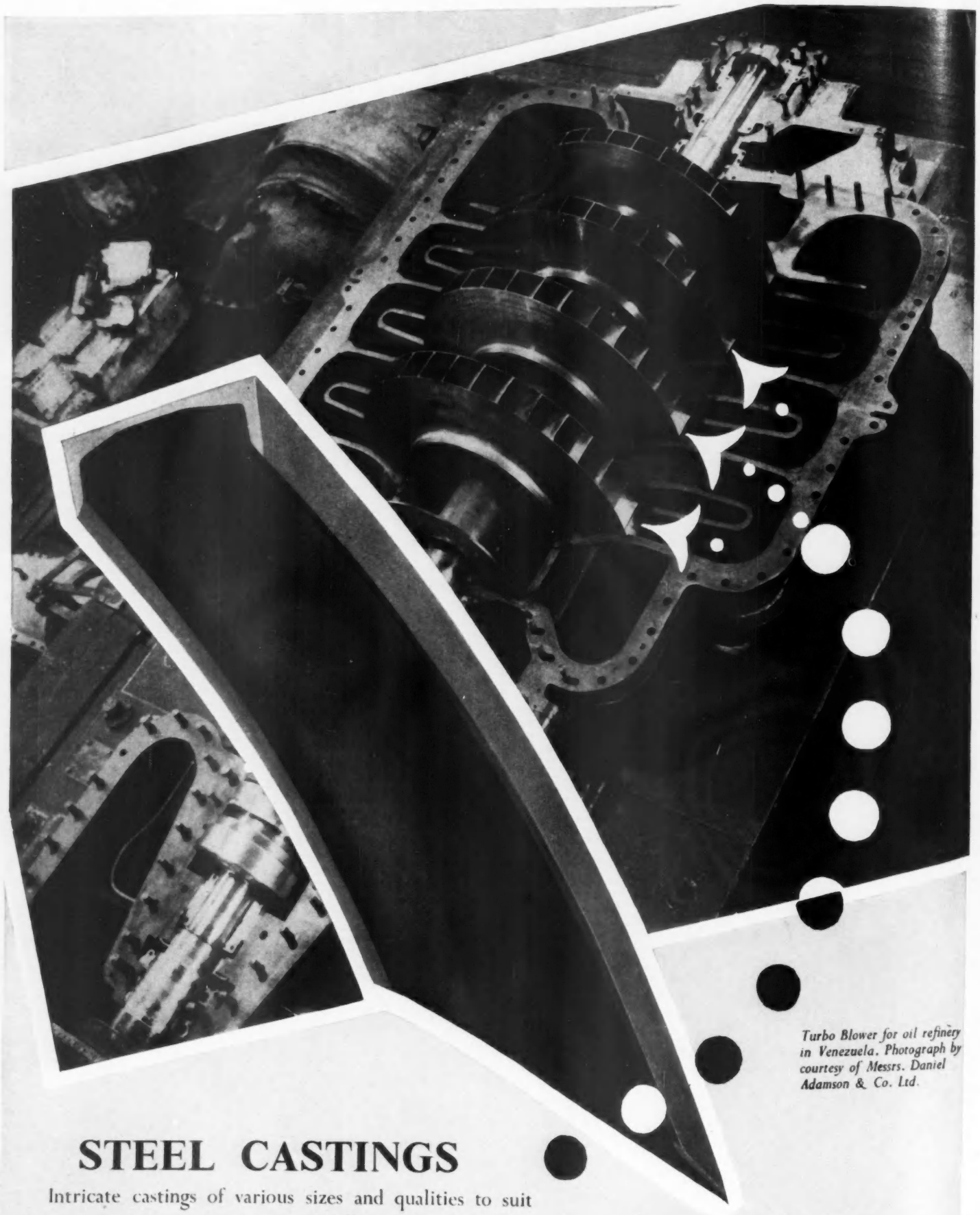

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THE ENGINEER

Established 1856

No. 5391 MAY 22, 1959 VOL. 207

EDITORIAL CONTENTS

Leading Articles

Vigour in Machine Tools 791
Contractors and Transport 791
Future of Professional Metallurgy 792
Reductio ad Absurdum 792
Education and Careers Exhibition 793

Articles

100 Years Ago 793
Nuclear Reactors for Marine Propulsion. No. II 794
International Convention on Transistors 796
Conference on Investment Casting 798
Temple Mills New Hump Marshalling Yard. No. II 799
International Transistor Exhibition. No. I 802
B. Wood Steam Turbine Runaways 805
Twin-Jet Aircraft 808
Heinz Factory at Kitt Green 809
Modification of "Zeta" 812
Moon as Radio Reflector 816
Institution of Metallurgists 816
Thermal Efficiency of C.E.G.B. Power Stations 816
Training in Radiation Dangers 816
Telephone Answering Machine 816
Fast Cargo Ship "Bulimba" 817
Electrical Installation Equipment 817
Kingston By-Pass Modernisation Proposals 817
Rubber-Bonded-to-Metal Laboratory 818
Heavy Duty Chain Factory 818
Printed Circuit Connectors 819
Electro-Mechanical Thrust Units 819
Elastomers Research Laboratory 819
Foundry Trades Exhibition 819

Continental Section

German Industries Fair, Hanover. No. IV 821
Process for Coal and Mineral Treatment 824
Petroleum Equipment Congress 824
German Welding Congress 824

American Section

American Nuclear Engineering Conference. No. II 825
Semi-Conductor Field-Effect Tetrode 827
Aluminium Armour 827

LETTER Road Safety 804

BOOK REVIEWS 804

OBITUARY Sir John Dalton, M.I.E.E. 815

NEWS AND NOTES Industrial and Labour Notes 820
Personal and Business 828
British Patent Specifications 829
British Standards Institution 830
Forthcoming Engagements 830
Advanced Engineering Courses 830

INDEX TO ADVERTISERS : PAGE 127 **CLASSIFIED ADVERTISEMENTS : PAGE 118**

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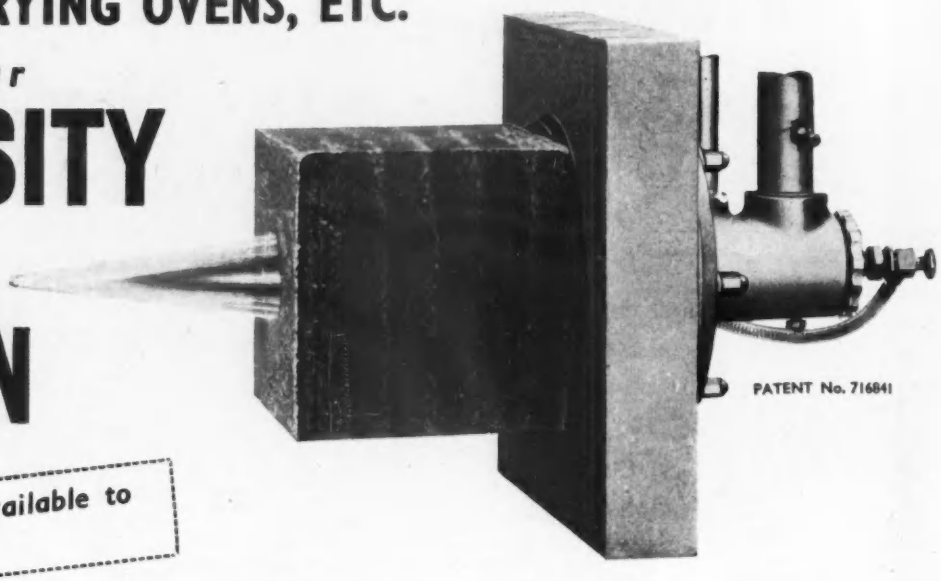

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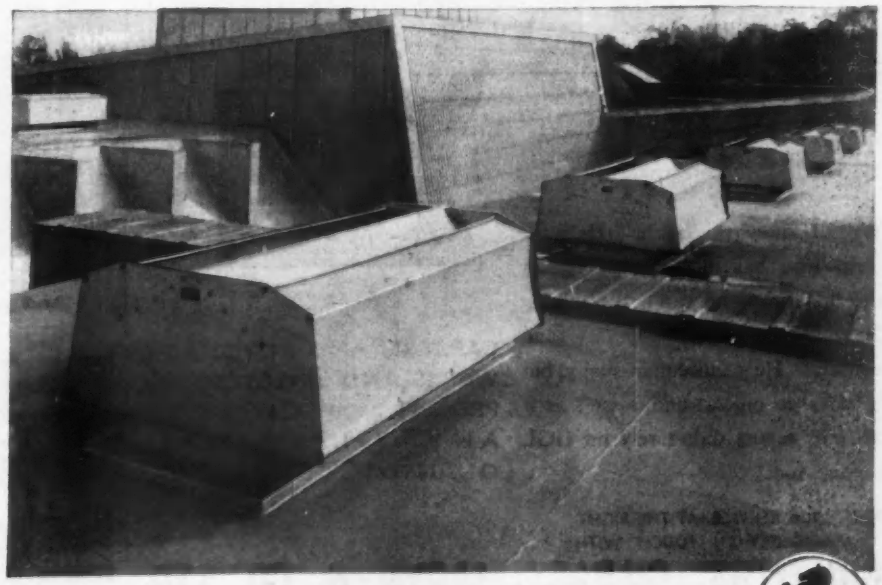

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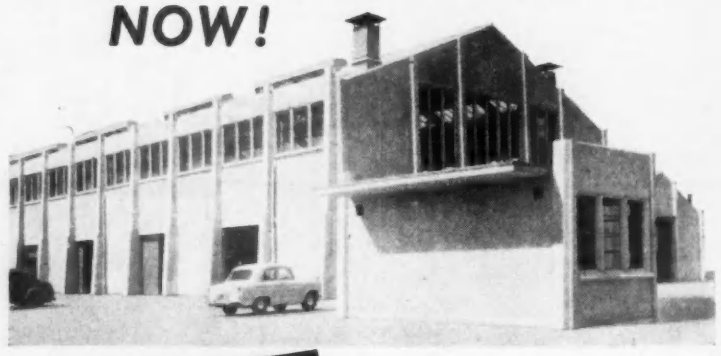

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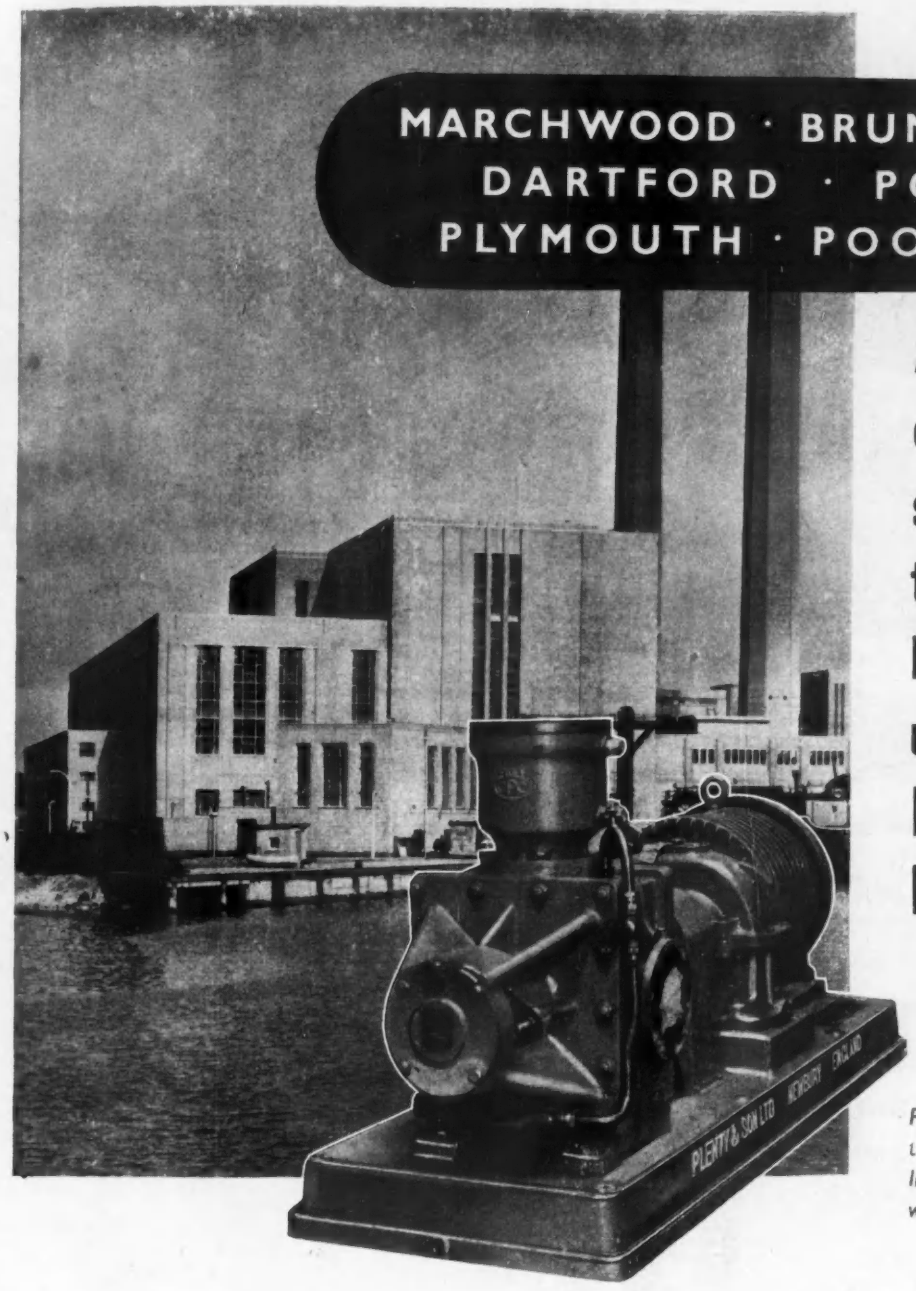

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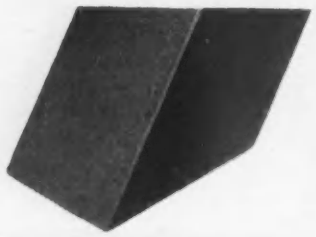

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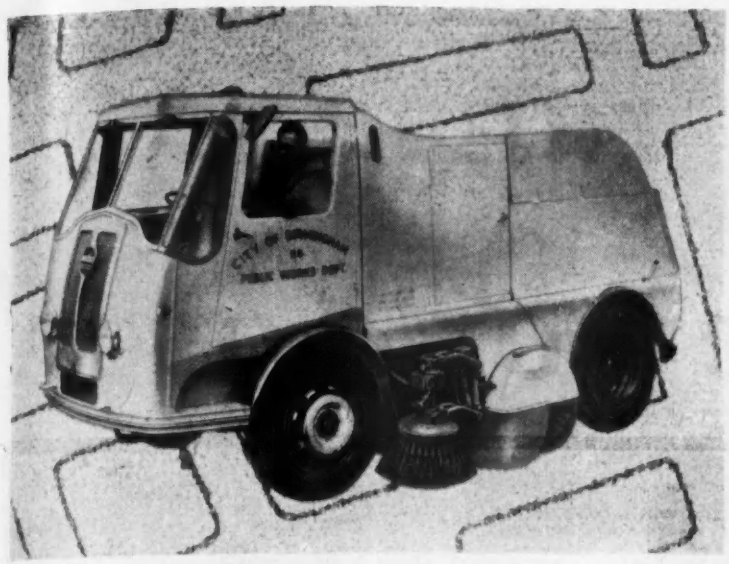

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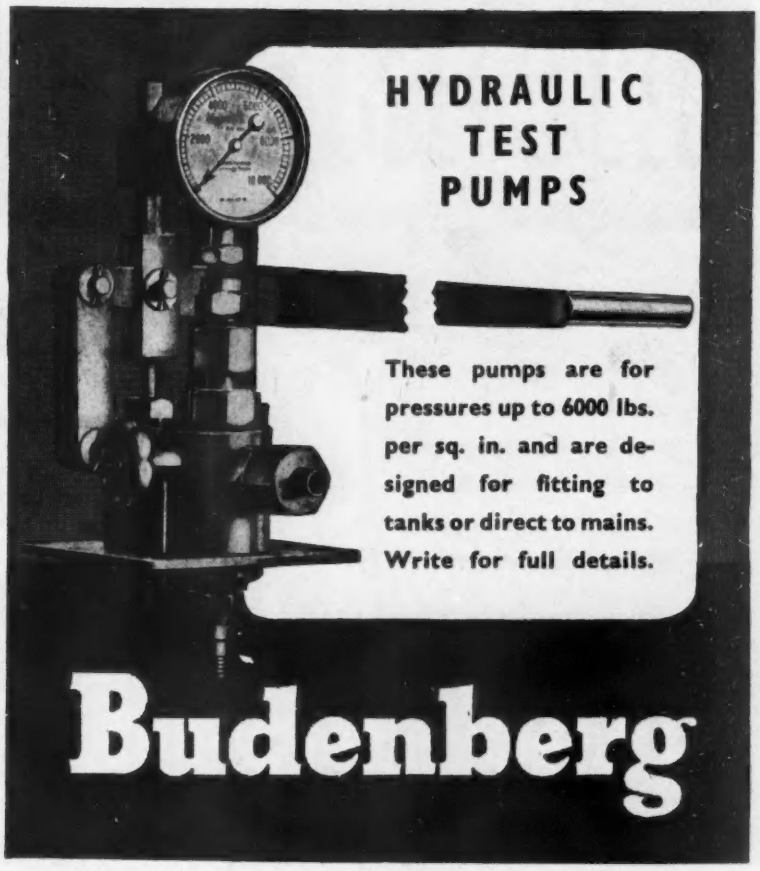
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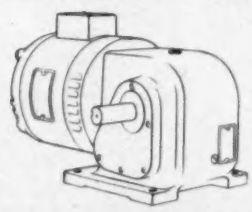

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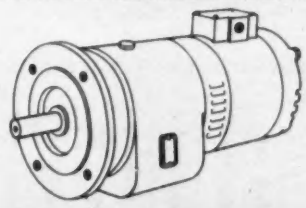

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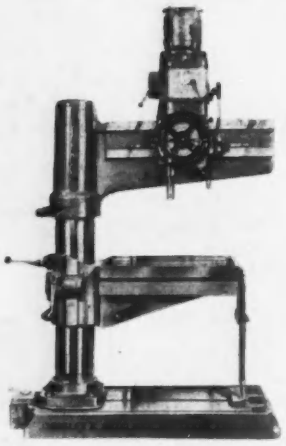

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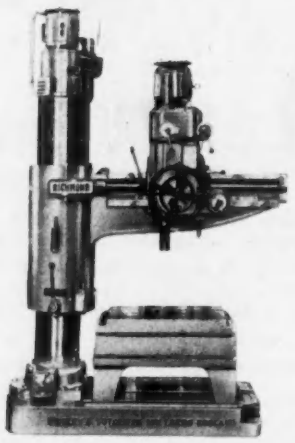

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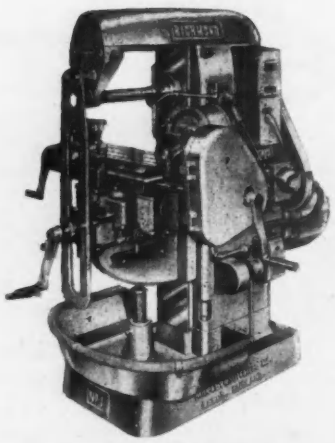

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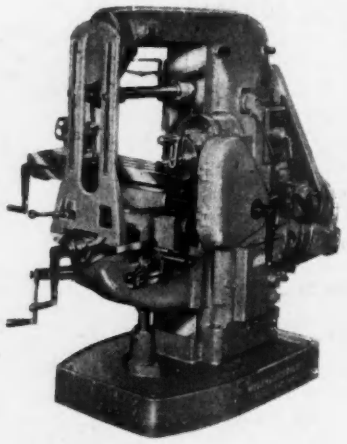

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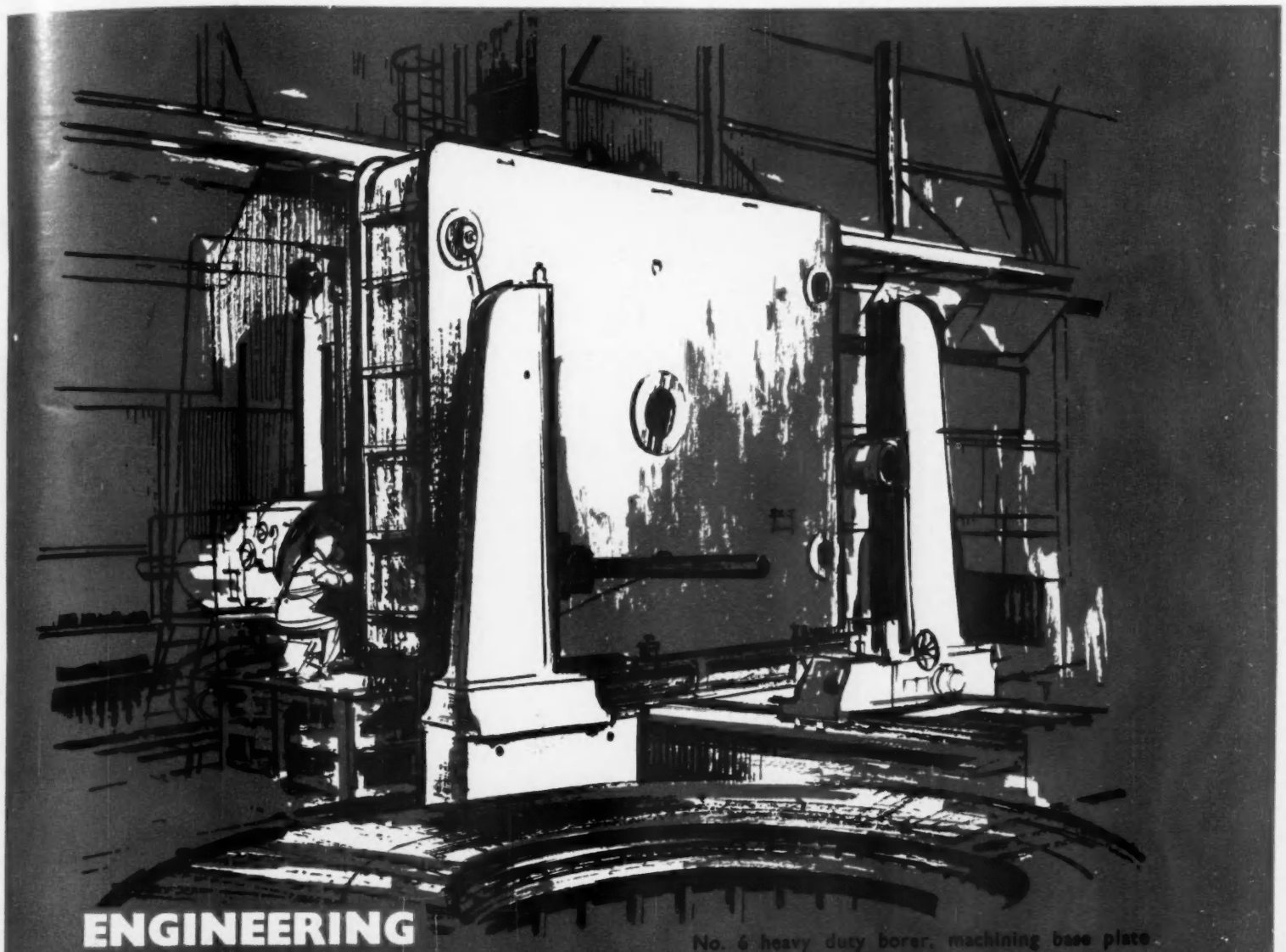

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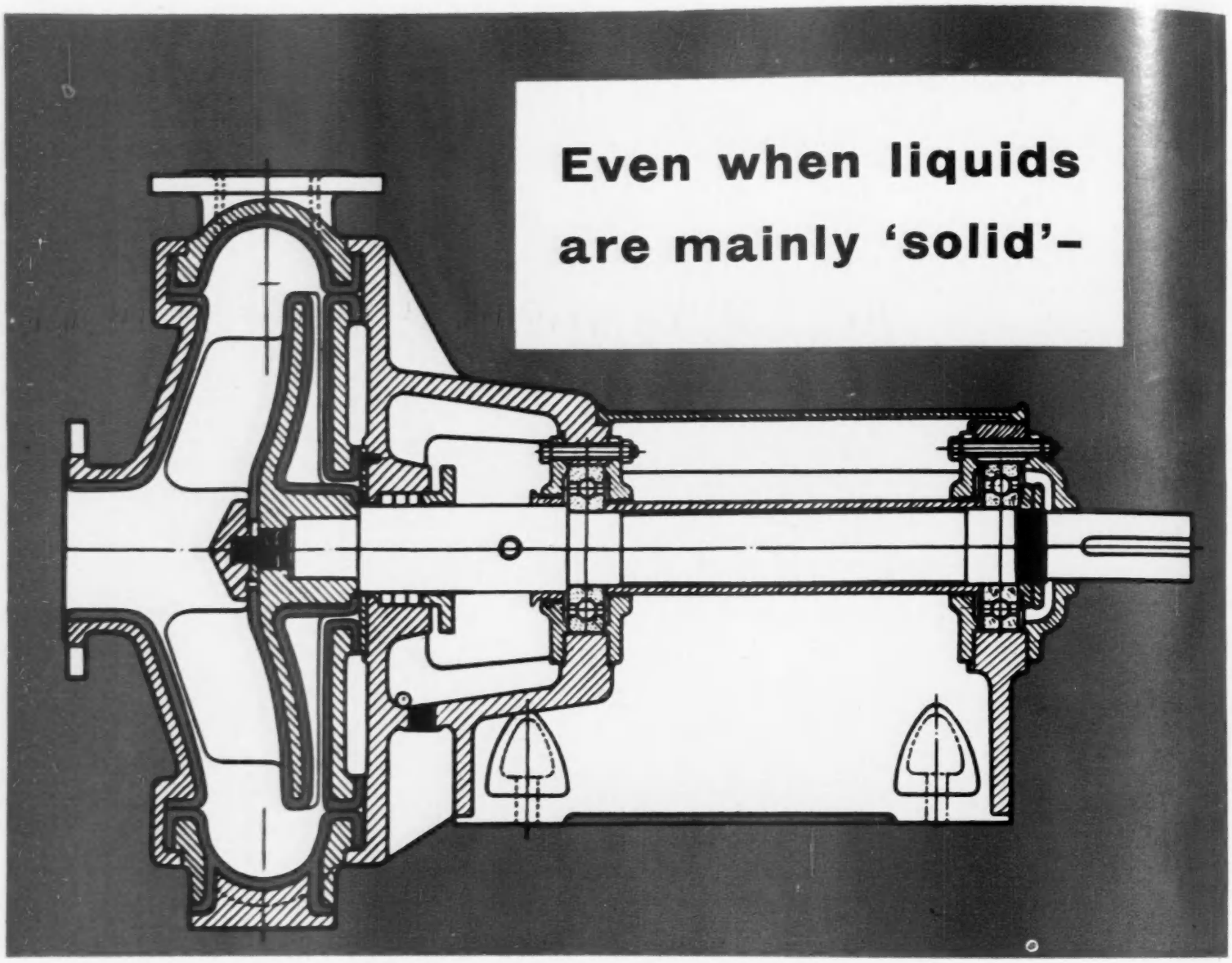

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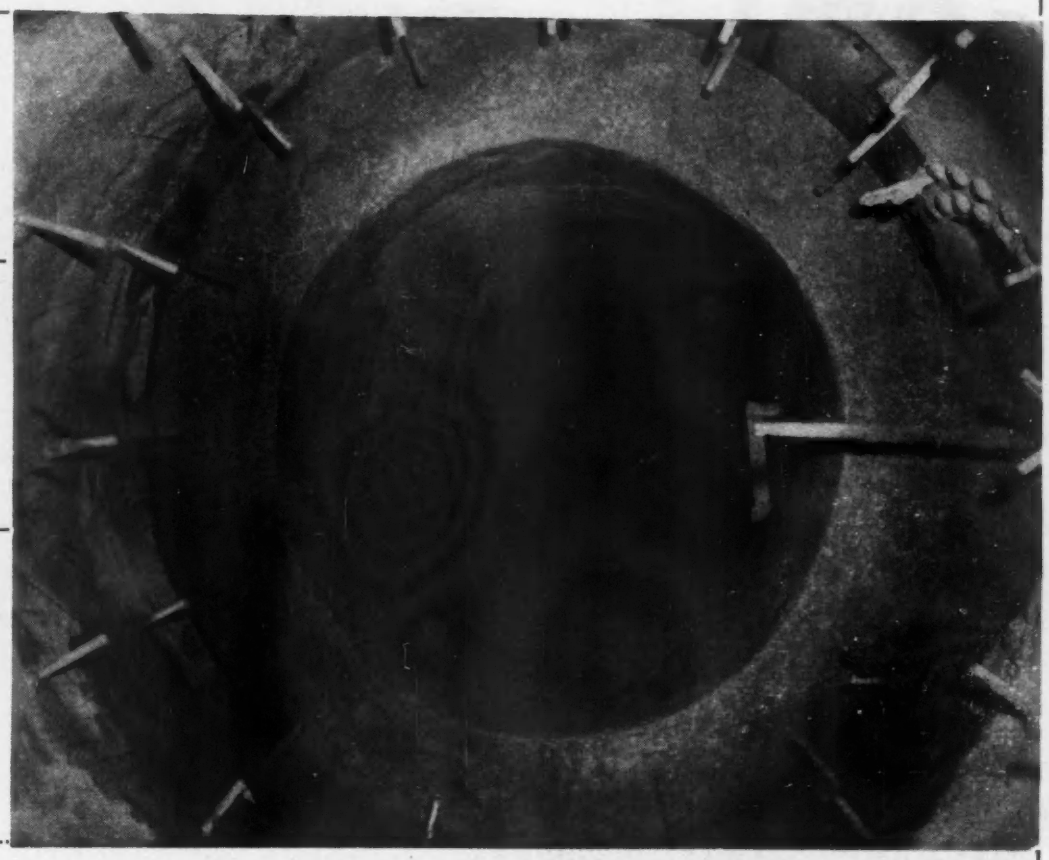

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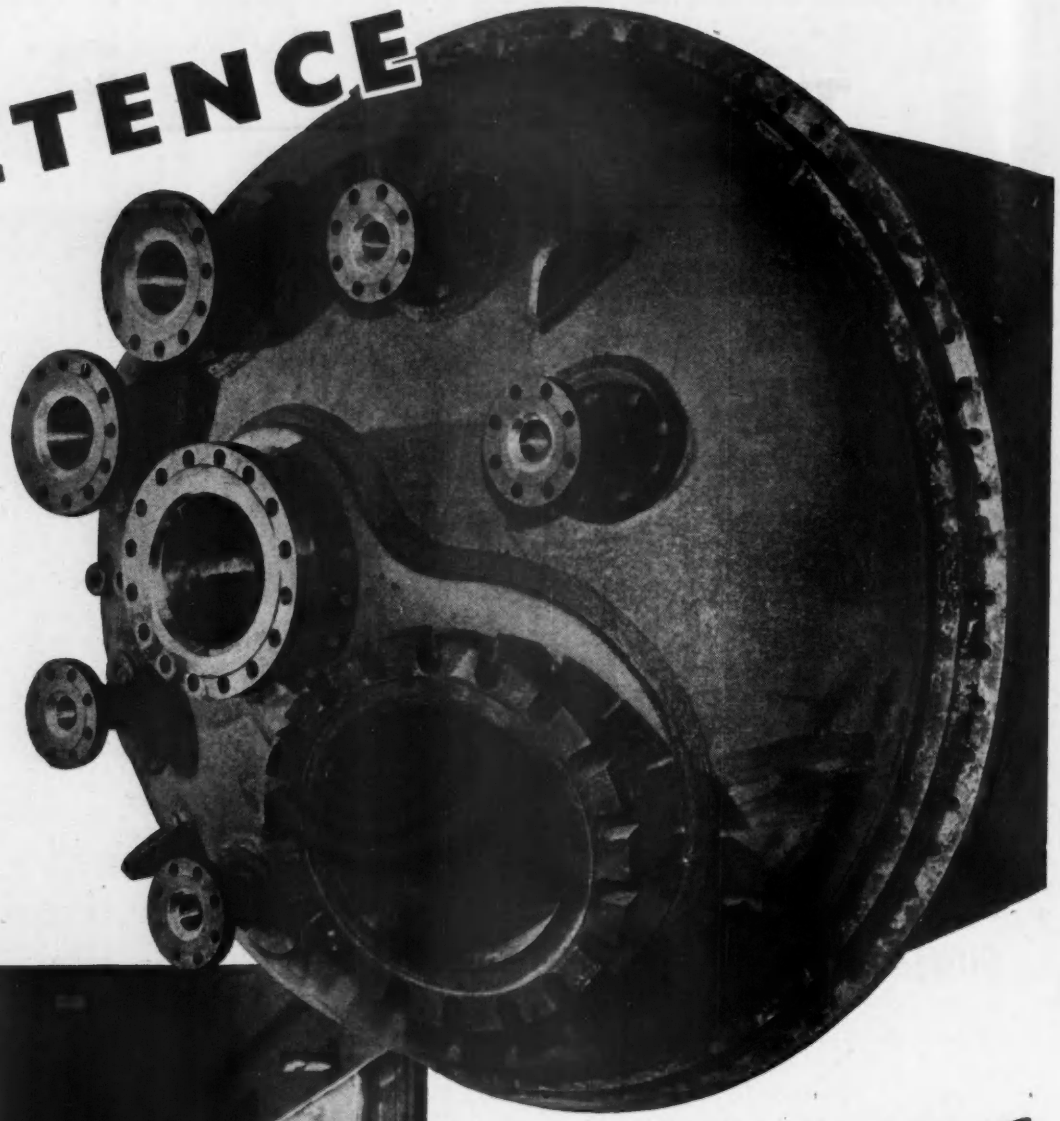

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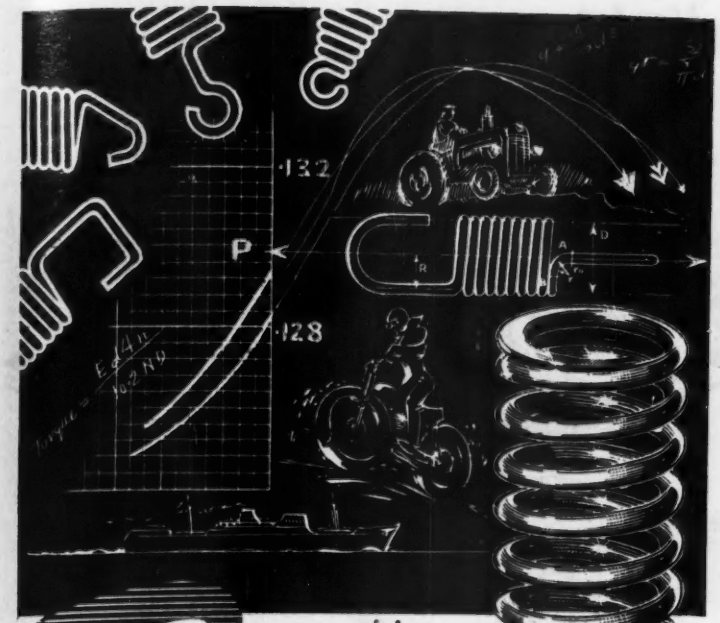

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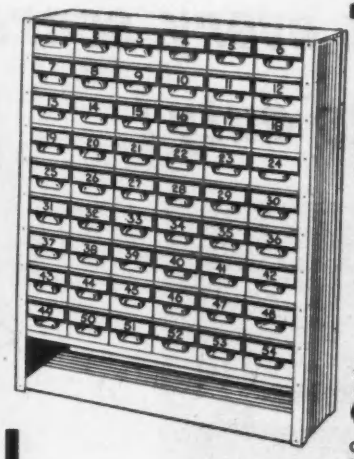

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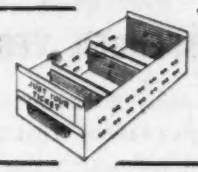

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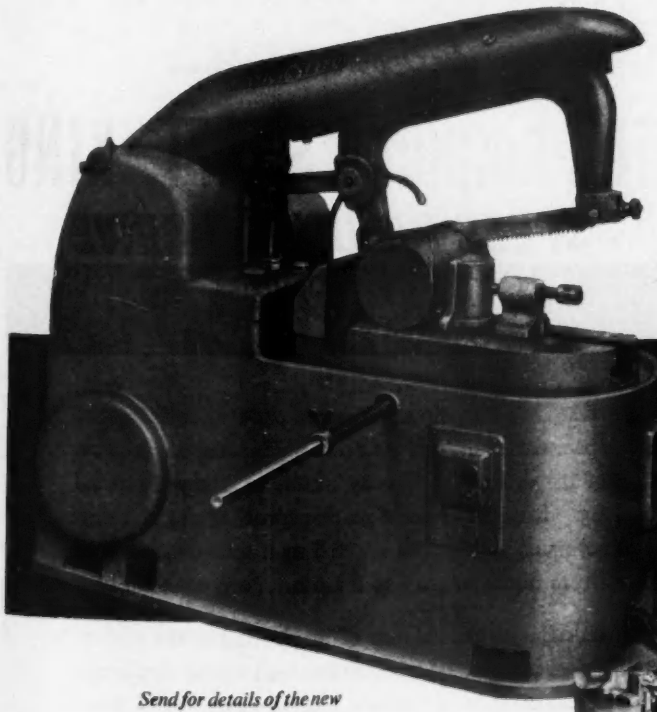

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The Wicksteed 8"×8" Hydramatic is the outstanding 1959 development in Sawing Machines and is the result of over 50 years' experience in metal cutting machine design and manufacture.

It is the most up-to-date advance on the highly successful Hydraulic Resistance type which has been in the lead of quality Sawing Machines for many years.

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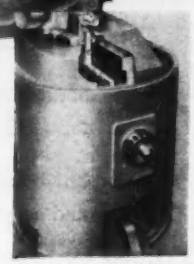
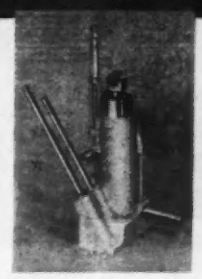
No. 8 — 8" × 8" CAPACITY



All Control Settings and Motor Starter accessible from one position only.

Adjustable motor trip switch allows machine to stop in any position at finish of cutting cycle.



Triple - Acting hydraulic unit enables blade pressure to vary according to section being cut.

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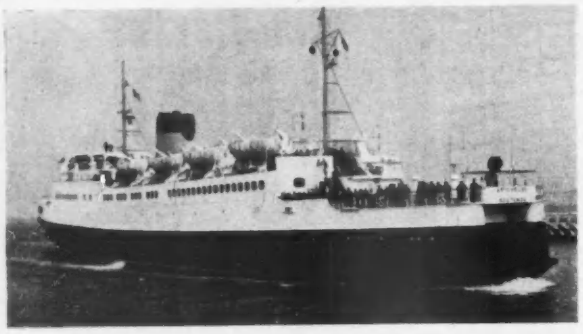

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Reliability of the searchlight is particularly vital on passenger carrying vessels. That is why so many companies specify and ensure that L.E.F. searchlights are fitted.
The motor ferry "Artevelde," one of the latest vessels of the Belgian Railways & Marine, carries a powerful L.E.F. searchlight which has a 24" diameter mirror and combined automatic and hand feed arc lamp (*see illustration*). The "Artevelde" is on the Dover-Ostend line.
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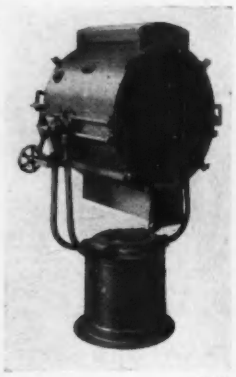

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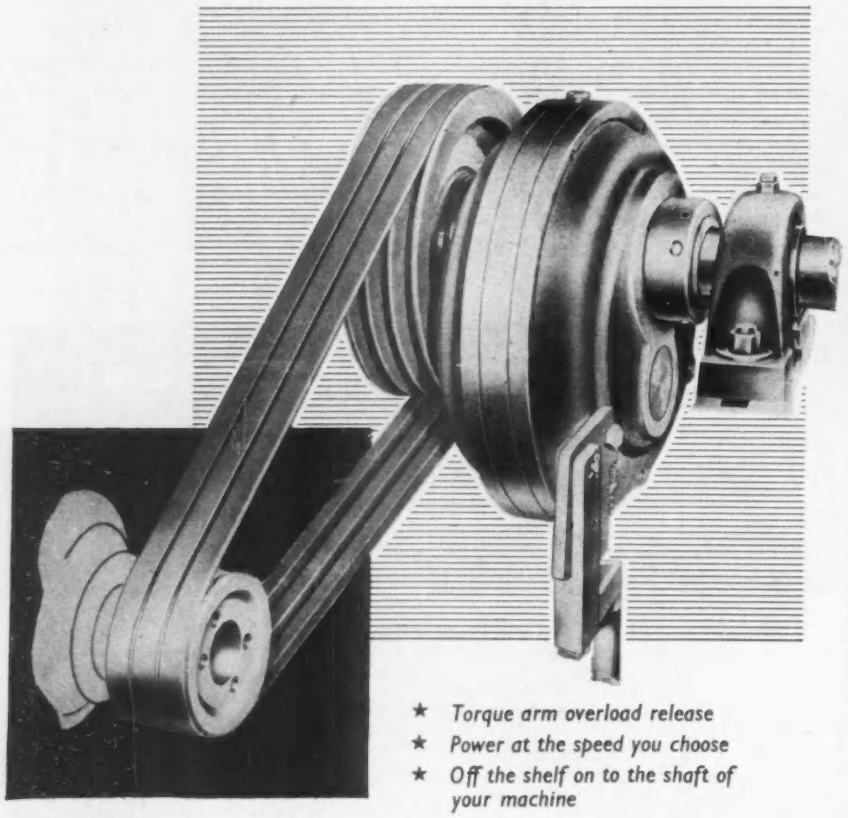

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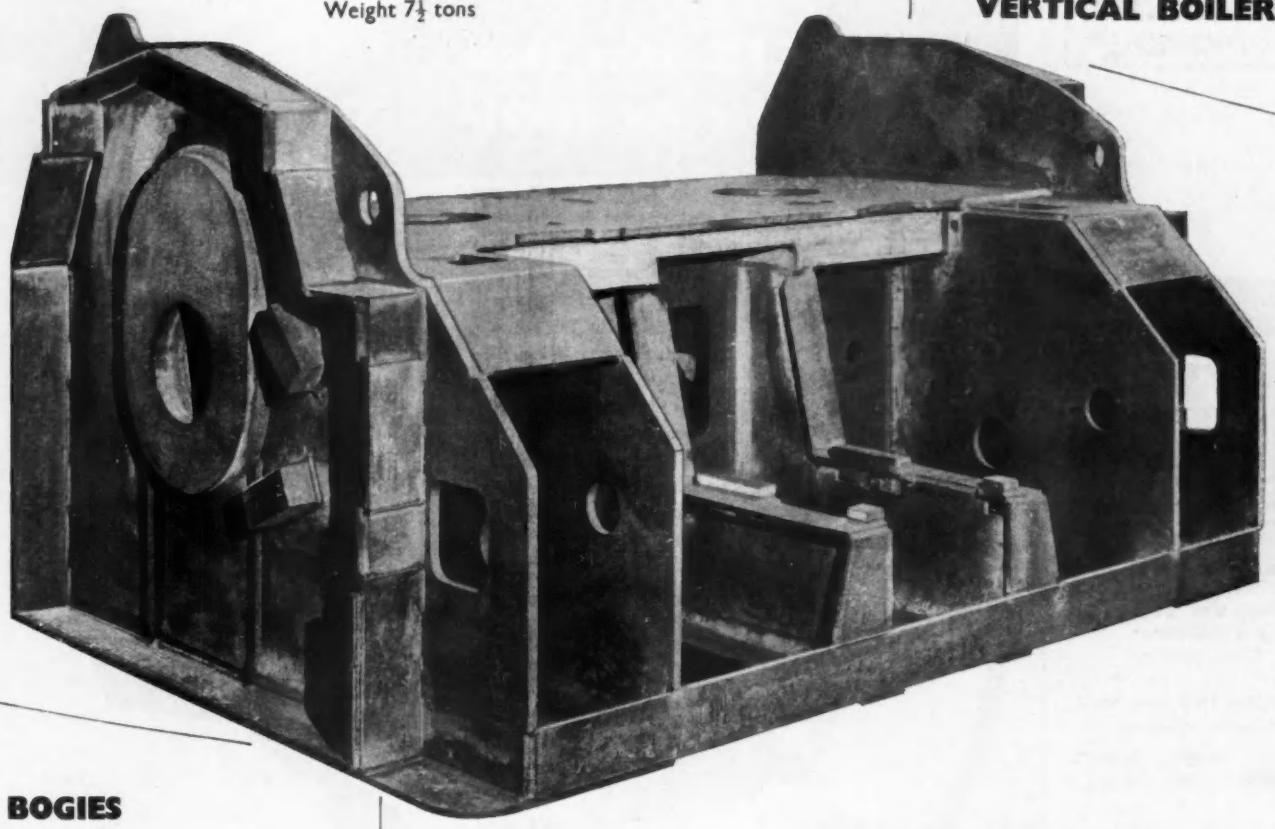

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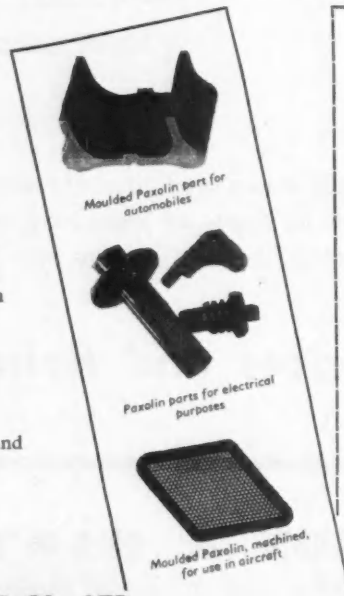

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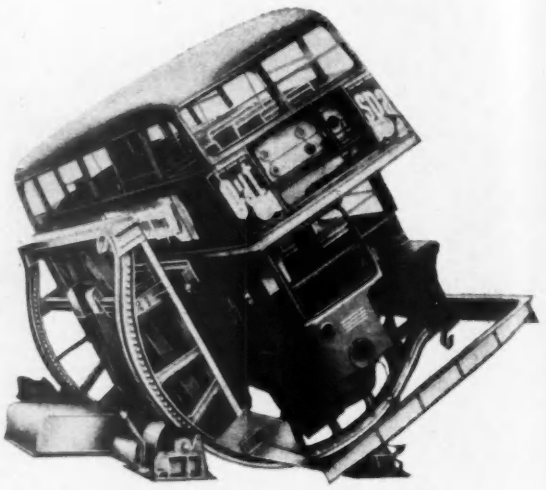
KING overhead runways, pulley blocks and conveyors in the factory—these are everyday requirements. But KING also make specialised equipment. Soundproof doors, flameproof hoists, bus tippers . . . not to mention pneumatic handling equipment, swarf conveyors and even hoists for television lighting.



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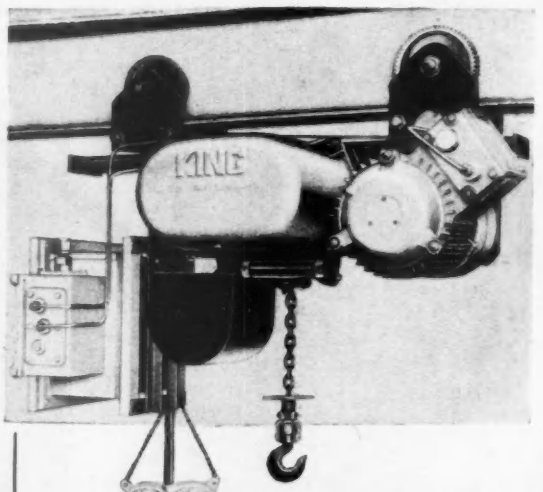

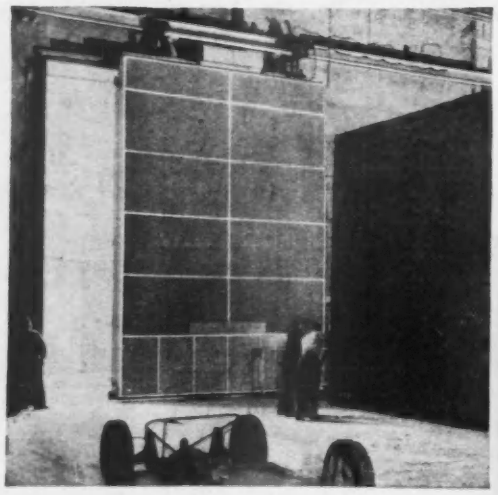

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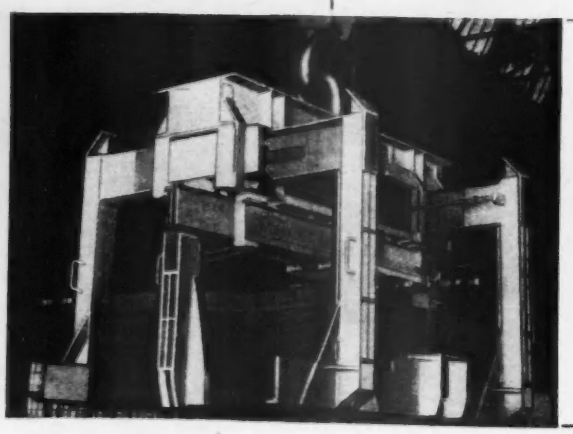

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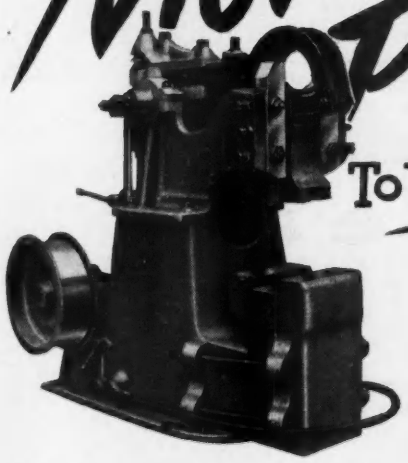

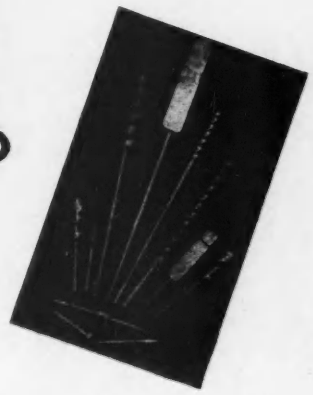

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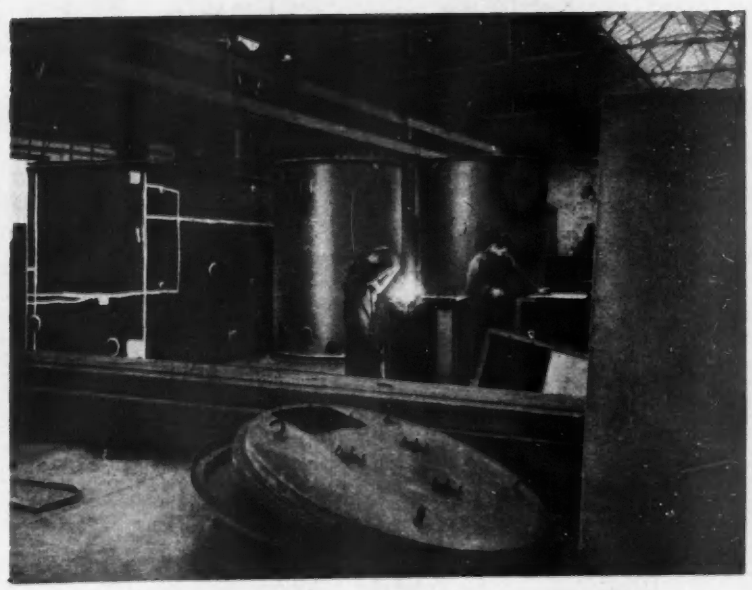

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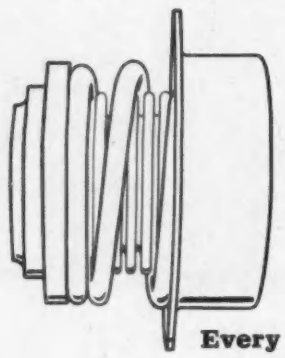

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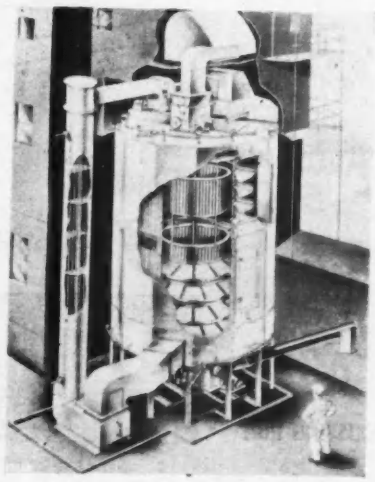
for fast, efficient, economical drying

Sturtevant have an agreement to manufacture and sell the Wyssmont Turbo-Dryer. This dryer is used extensively in the U.S.A. and elsewhere on a wide range of high grade chemicals.



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- No overheating
- No excessive fines
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- No excessive caking

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is particularly suitable for products that are :

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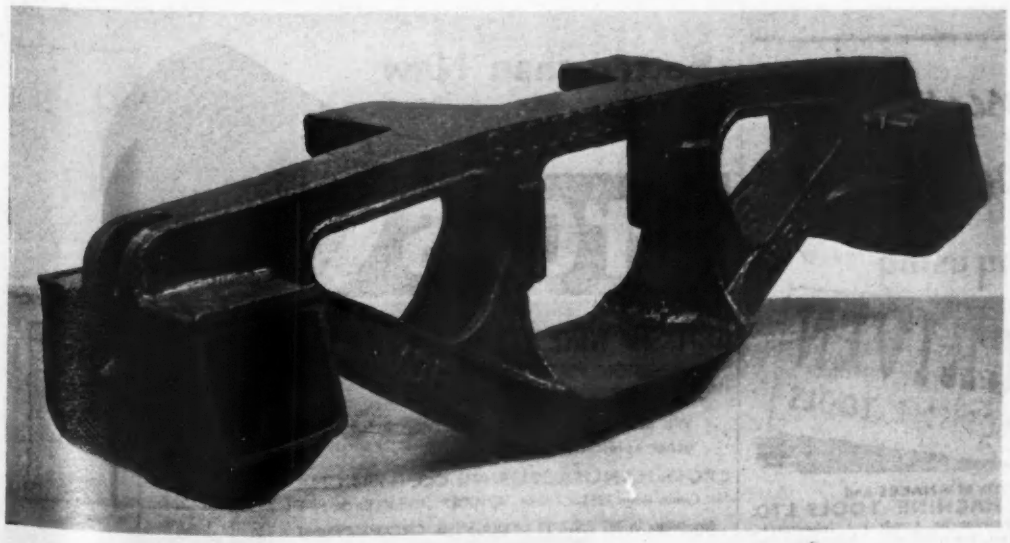

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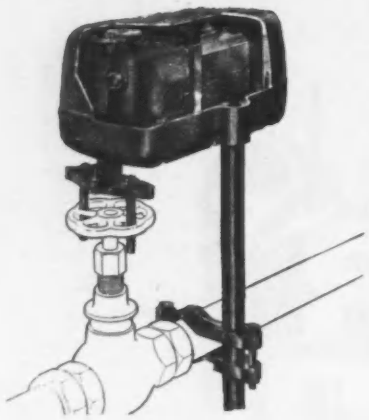

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Rotork electric actuators can be operated by push button, or automatically from any distance.

The "Junior" model illustrated (type 1F) will operate any valve with a handwheel which a man can close with one hand. No modification to the valve is needed.

A worm and spur type reduction gear box, grease packed and totally enclosed in a weatherproof case, is driven by a small universal type motor suitable for 200-250V. A.C. single-phase supply.

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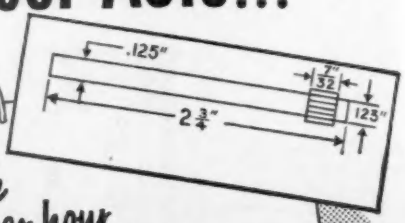

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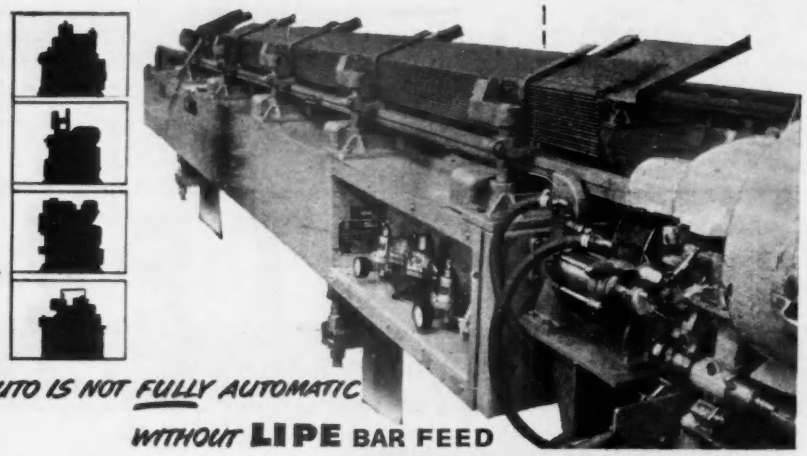

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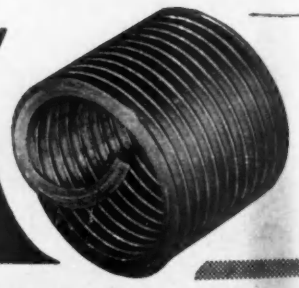

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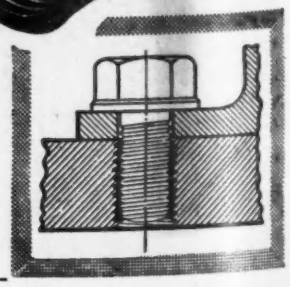

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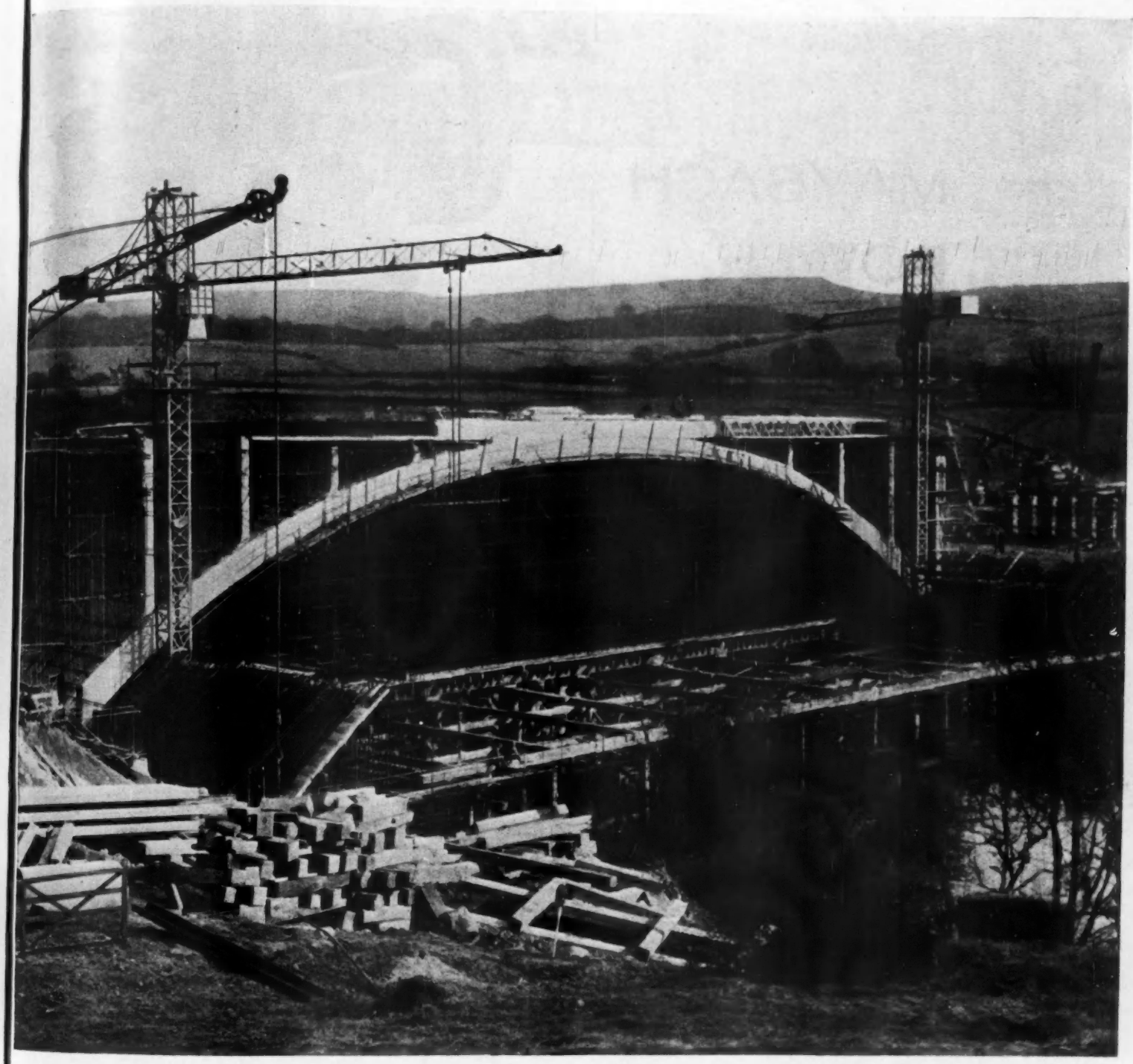

Photograph by courtesy of James Drake, B.Sc., M.I.C.E., M.I. Mun. E., County Surveyor and Bridgemaster

The Lune Bridge...

. . . carrying the twin carriageway of the Lancaster By-Pass over the River Lune is just one of the 27 road and railway bridges included in the 11.62 miles of the Lancaster By-Pass. This work is being undertaken by Sir Lindsay Parkinson & Co. Ltd. for the Ministry of Transport and Civil Aviation through the Lancashire County Council at a contract value of £3,250,000.

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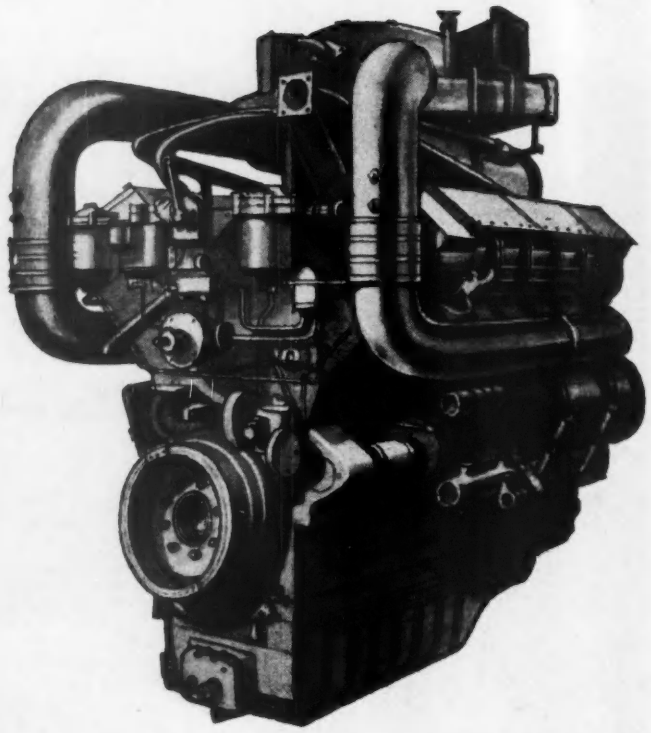
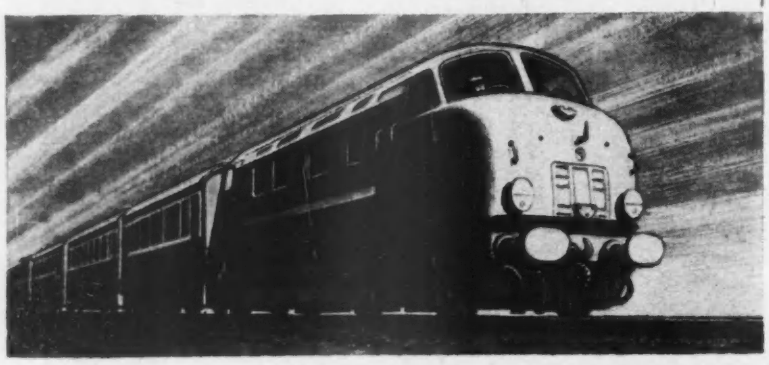


Typical of the MD range of engines is this Type 650 12 cylinder supercharged model with cylinders arranged in 'V' formation.



◀ Railway Traction 220-2,000 B.H.P.

Industrial Plant 220-1,750 B.H.P. ▶

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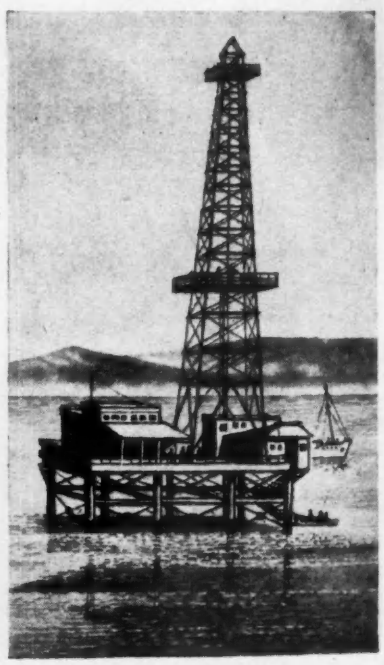

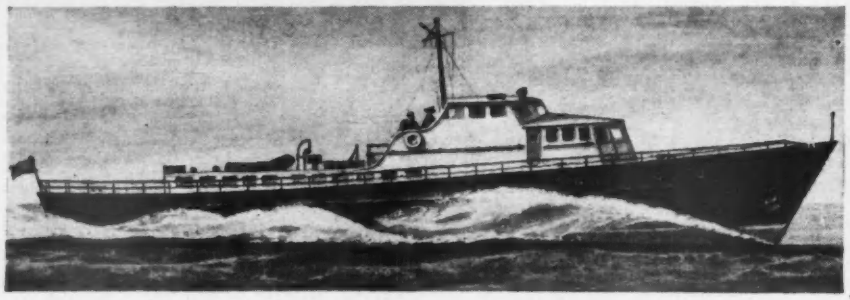

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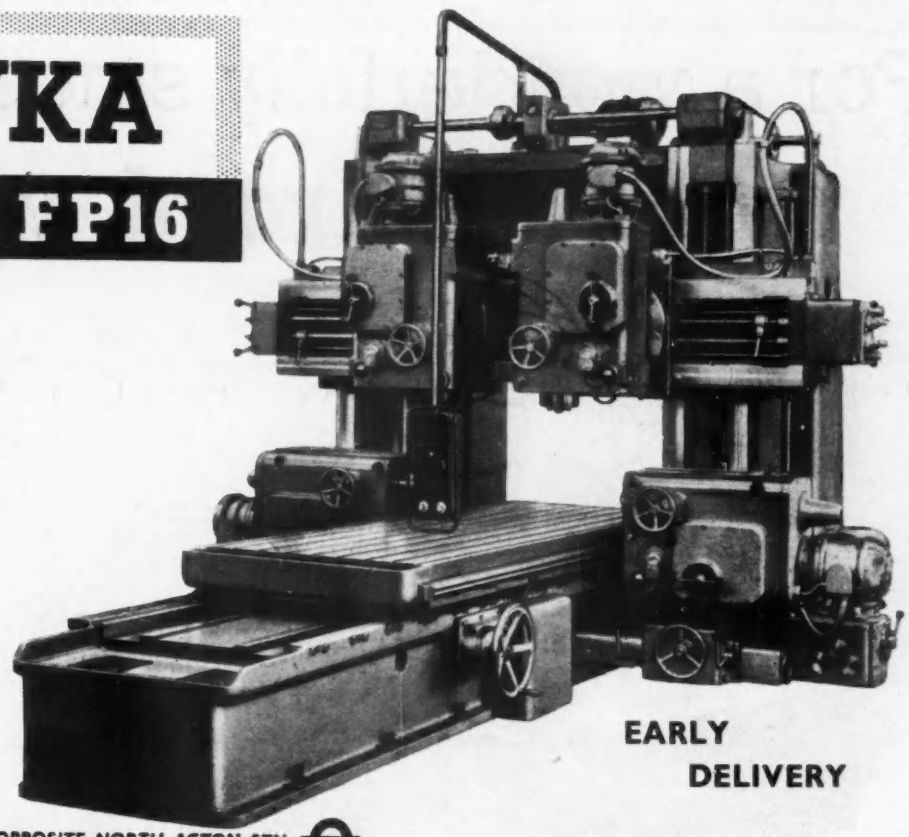

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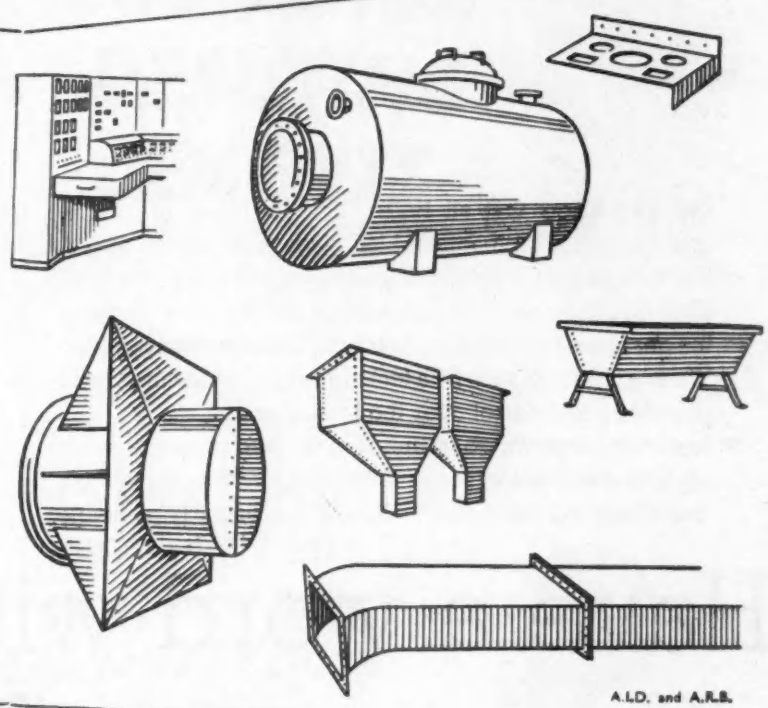

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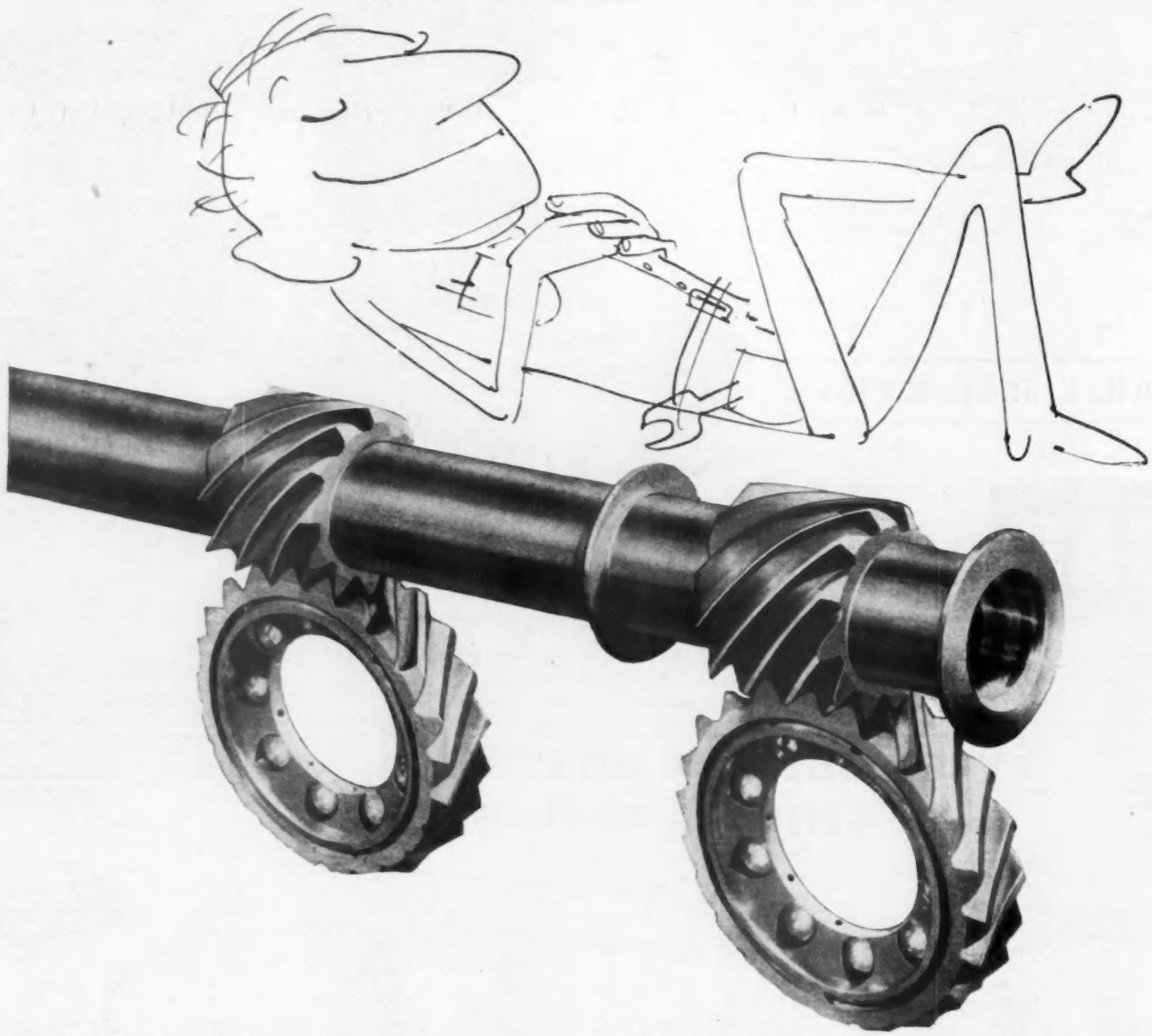

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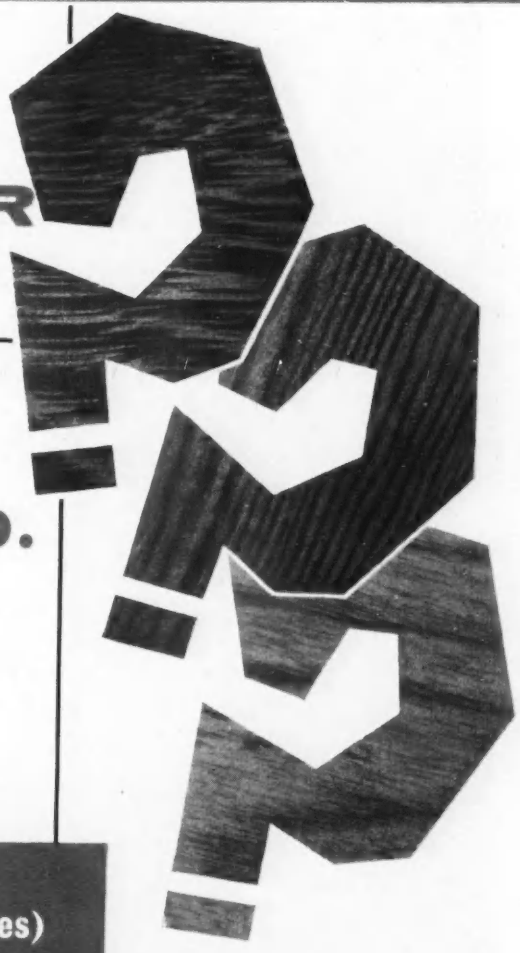

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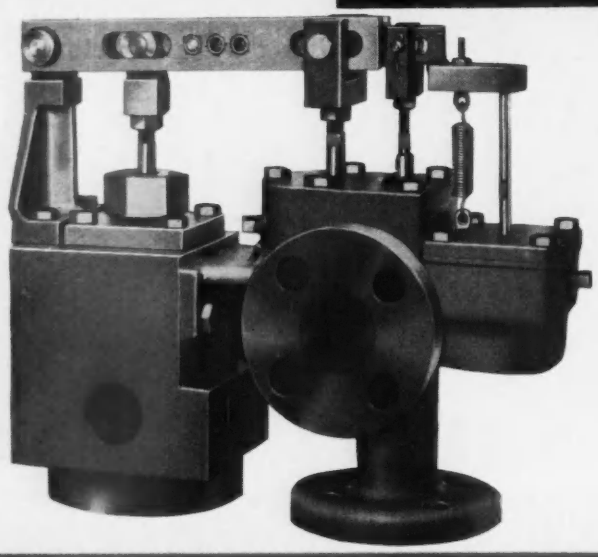

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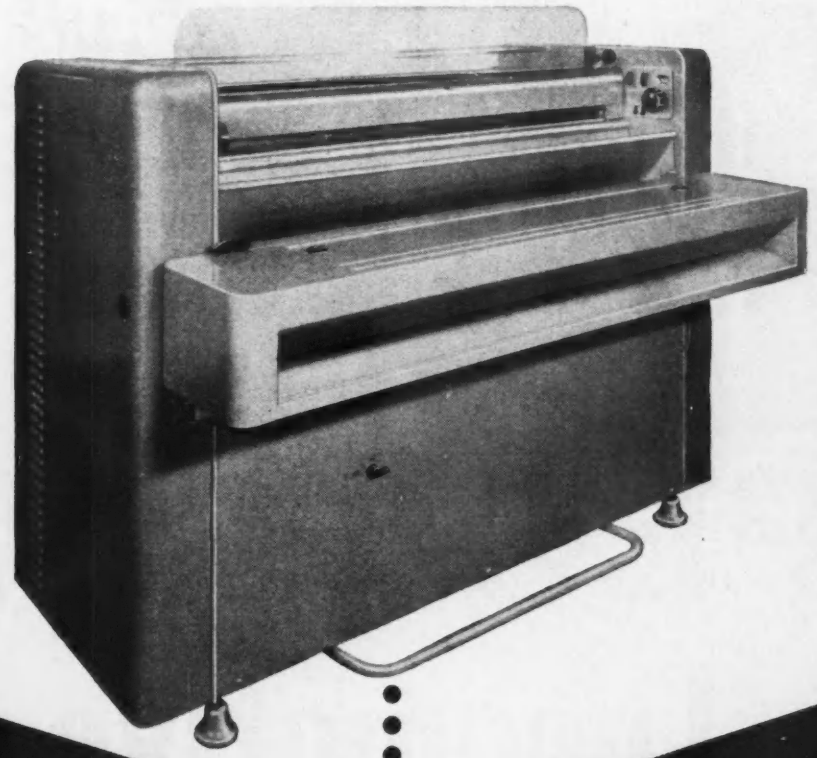

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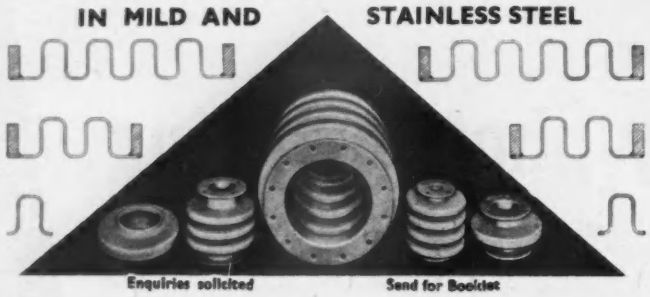

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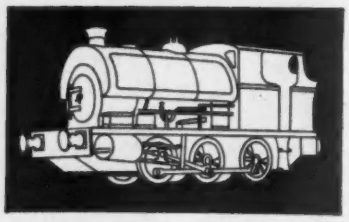

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Coverage	Extremely Uniform

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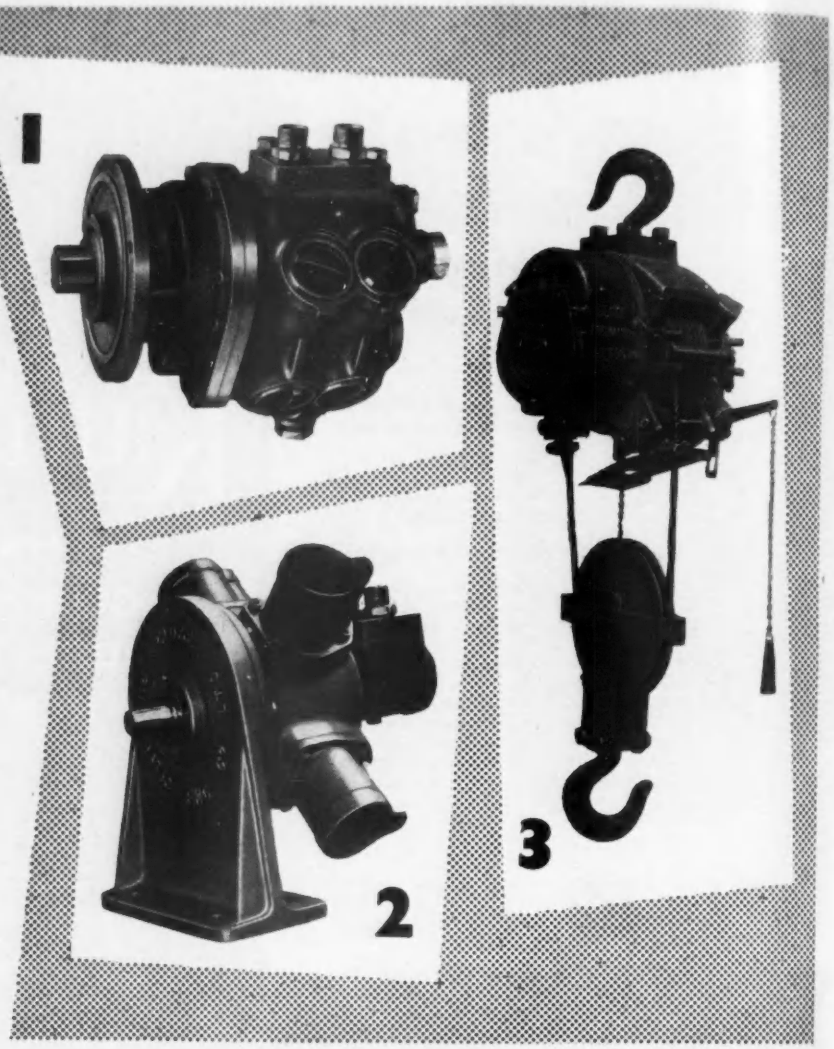

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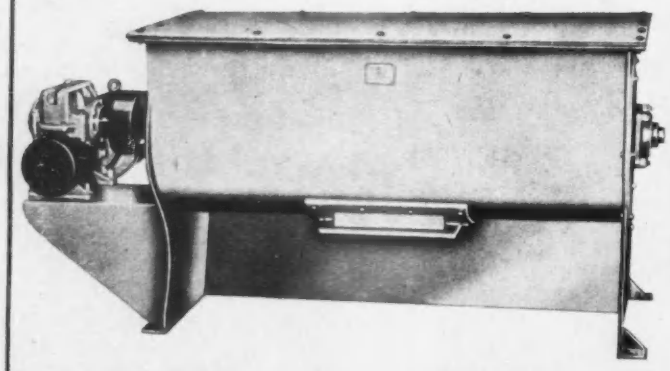

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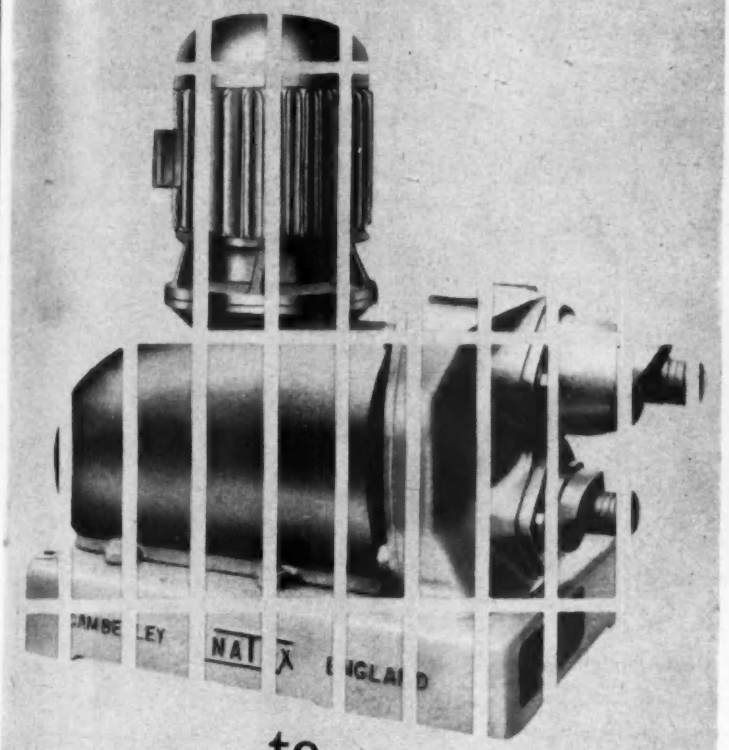

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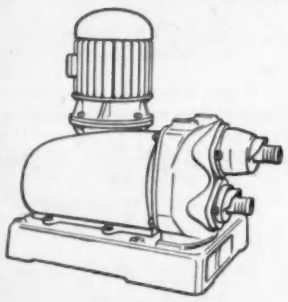

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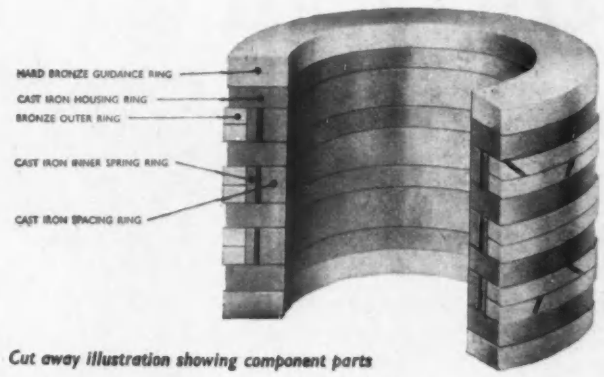

Cut away illustration showing component parts

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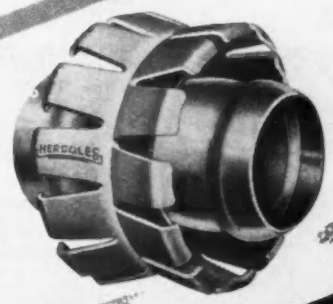

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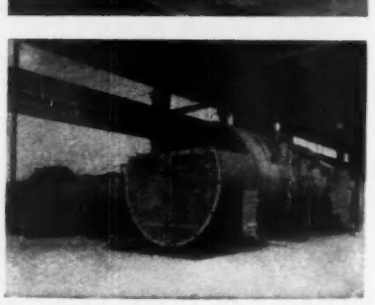
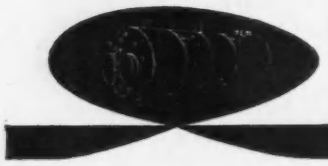
The straight-through fire tubes have a high ratio of length to bore, giving about 90% tube efficiency and providing a large area of heating surface in a comparatively small space. Brickwork setting is not required and air infiltration is thus avoided.

A feature of Joseph Adamson Waste Heat Boilers is that a special cleaning device can be provided in the outlet chamber to allow the tubes to be cleaned while the boiler is at work.





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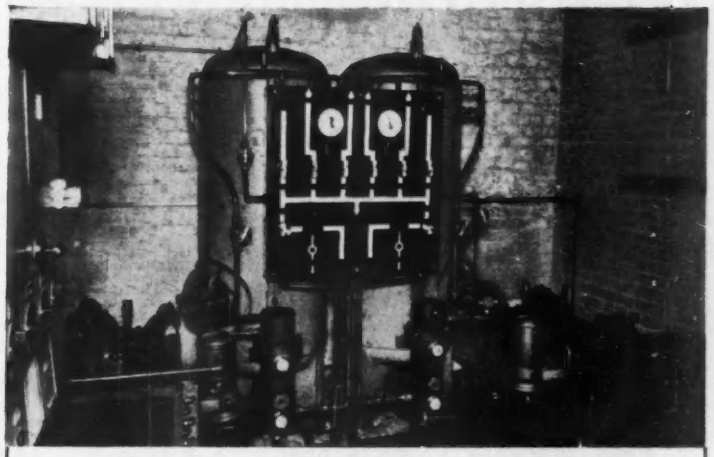
It's just plain good sense to fit Vokes filters in your air lines

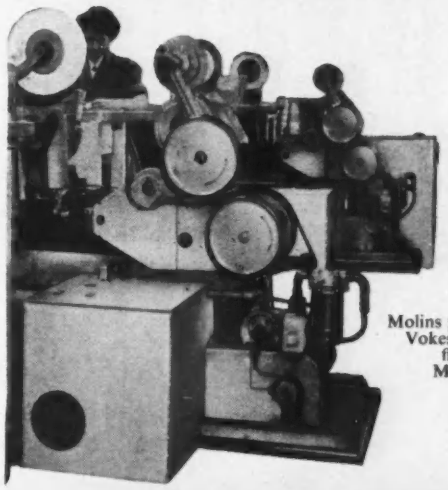
Yes . . . it's good sense to protect air-using plant and machinery against damage, when the protection costs so little. Vokes standard pipe-line filters for instance at strategic points along the line, prevent water, scale and rust from reaching compressed air tools and causing early breakdown and loss of efficiency.

And for special applications, such as in the manufacture and processing of chemicals and food, the packing of cigarettes, there are Vokes pipe-line filters with special silver grey paper elements, excluding not only the "major menaces" but also oil mist and minute particles of foreign matter which present a hazard to the product or the process.

Fit Vokes pipe-line filters—maintain them regularly—and their installation will be repaid a hundred times over.



SWITCHGEAR: Vokes C.P.H. filters fitted in an air-operated switchgear room at Kingston power station.



CIGARETTE PACKING

Molins packing machine, showing Vokes Compressed Air Pipeline filter (Photo by courtesy of Messrs. W. D. & H. O. Wills)

VOKES

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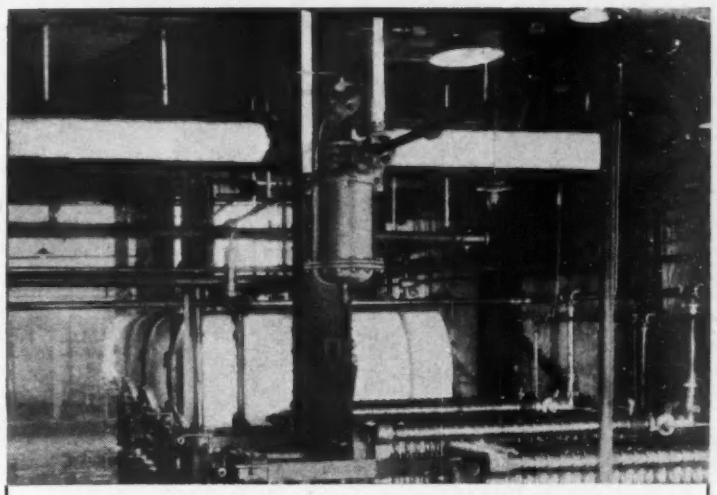
Give protection all along the line



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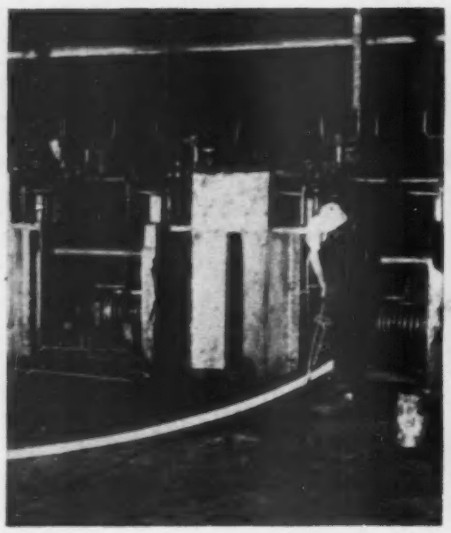
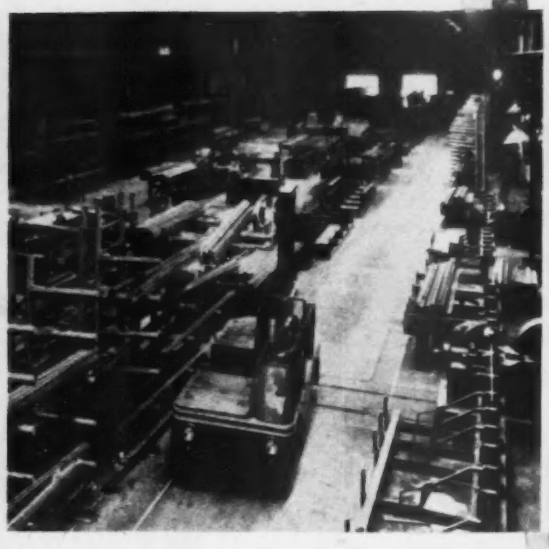
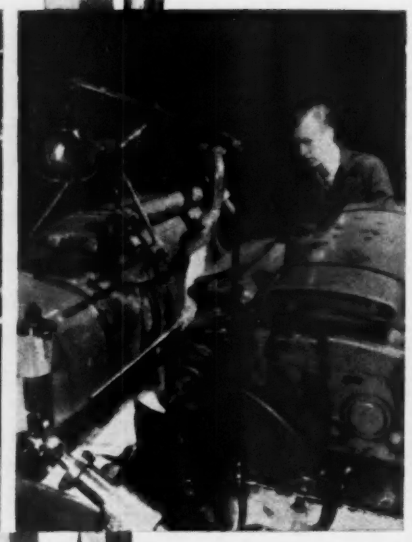
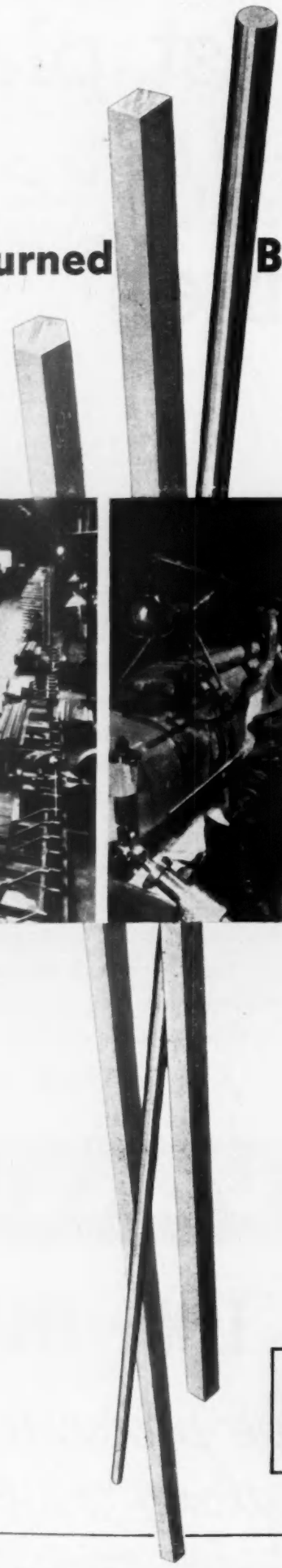
V334

Precision ground and Centreless turned Bars









Makers of Precision Ground Bars in many qualities of Carbon and Alloy steels to tolerances varying from ·00025″ to ·001″ ±, as specified.

Centreless Turned and Cold Drawn Bars are also supplied, the former to limits ± ·004″ and the latter to limits ± ·002″.

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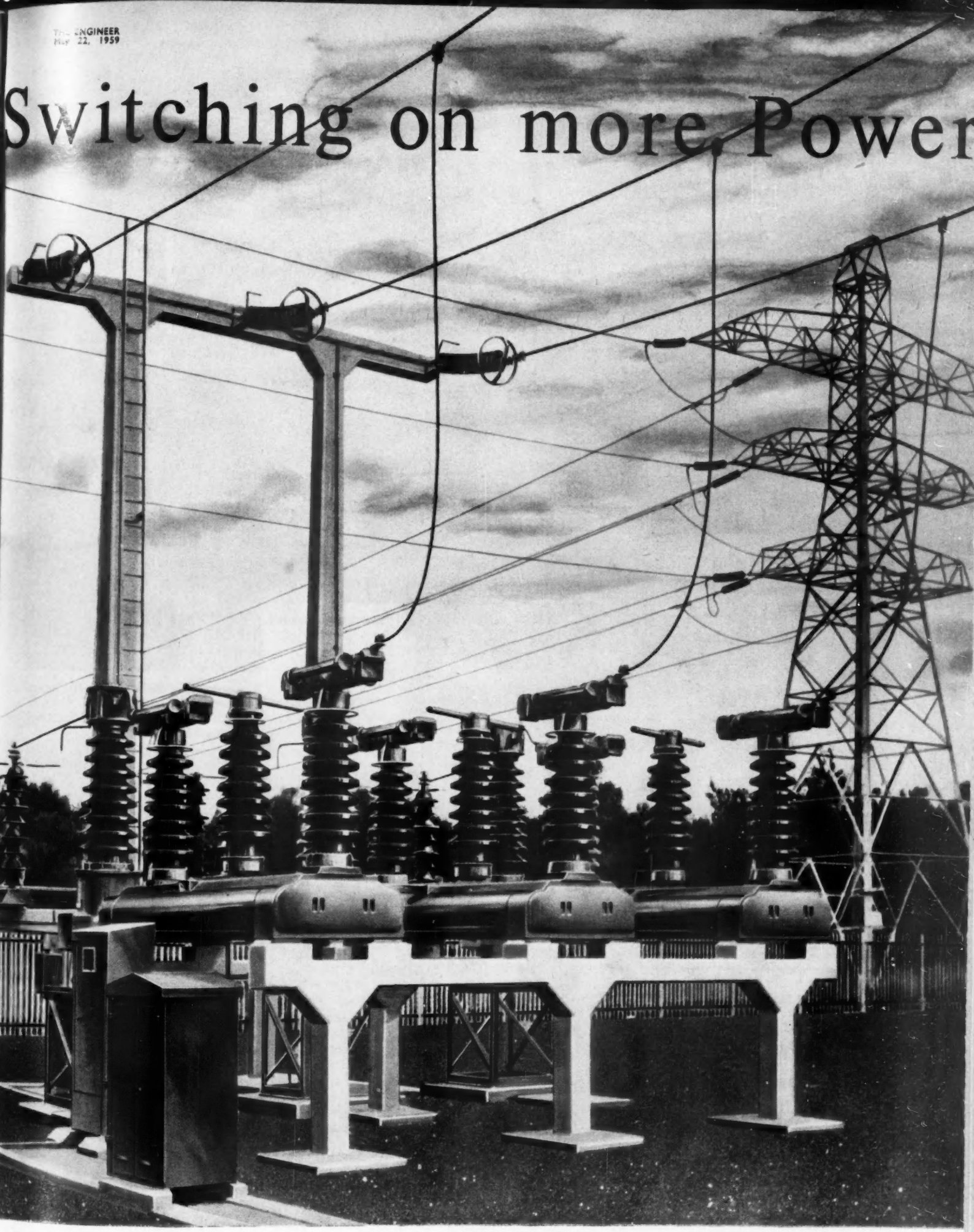

The photograph shows a Metrovick 132 kV., 3,500 MVA., Type GA6W4 Air-Blast Circuit Breaker installed in a British substation

This type of breaker is in extensive use on the British grid system, and has been selected to control the output of Scotland's first Nuclear Power Station at Hunterston. Overseas, 132kV., 5000-MVA., Type GA6W4 breakers will be installed in seven new sub-stations in the Greater Buenos Aires area of Argentina.

METROPOLITAN-VICKERS
ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER 17

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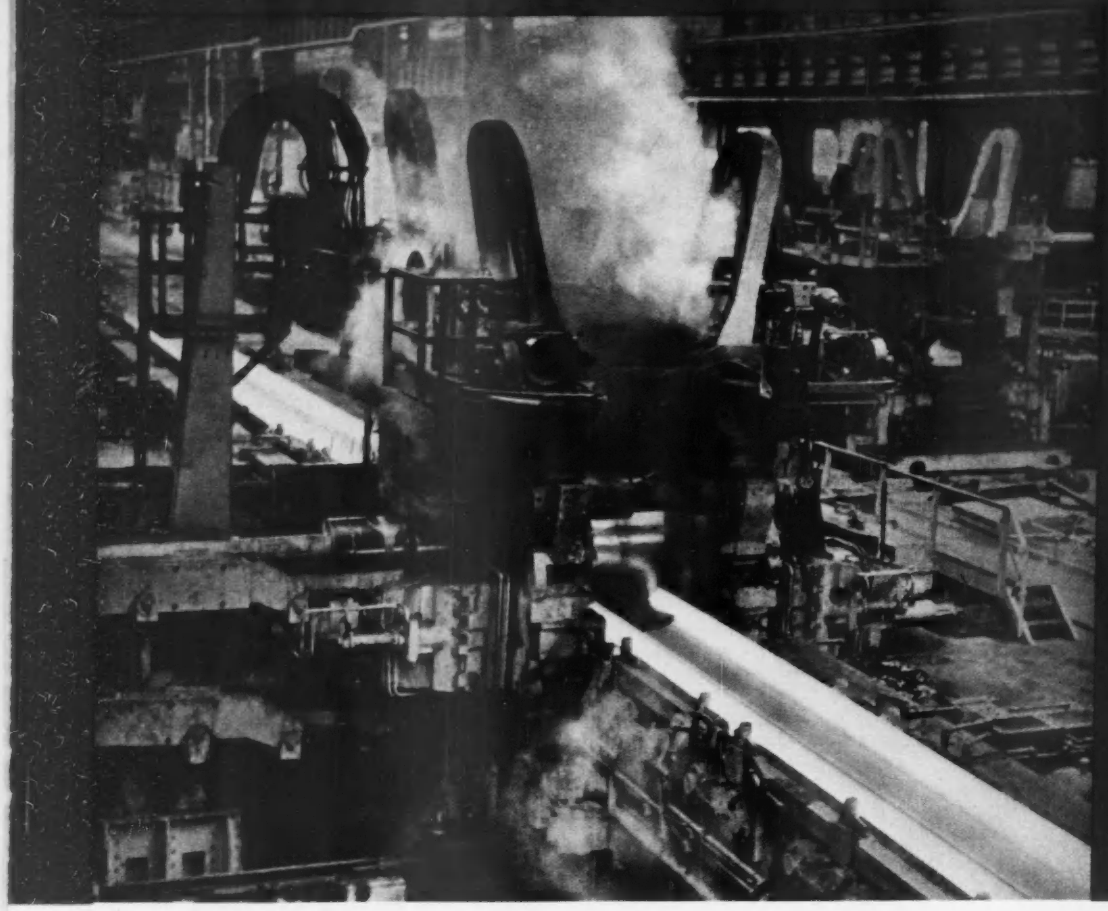
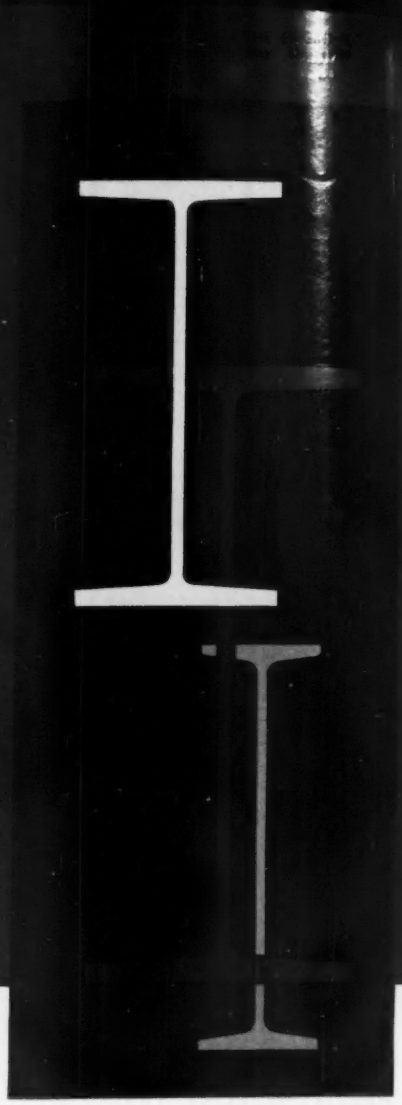




Above: in red, the new 36″ x 16½″ beam (shown in the rolling mill picture); in blue, the largest of the British Standard sections, 24″ x 7½″.

'UNIVERSAL' BEAMS

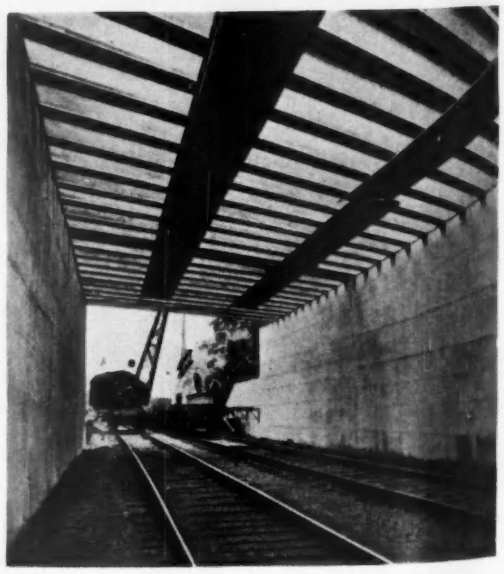
IN MANUFACTURE AND IN USE

Here is a 36″ x 16½″ 'Universal' beam passing through the finishing rolls of our Universal Beam mill at Lackenby.

It is the largest of our new range of sections—all carefully proportioned in the light of structural experience to simplify design and fabrication of steel structures.

The mill has important features which considerably augment its productivity and service to the industry: one is its construction with alternative sub-assemblies having rolls and bearings already mounted in interchangeable stands, thereby facilitating rapid changes. Another feature is the mill arrangement by which a beam or column section can be rolled in different 'weights' to suit different loads—yet without substantially affecting the overall dimensions.

A bridge at Catterick (shown below) recently built by Tees Side Bridge & Engineering Works Ltd., with spans of the new 24″ x 12″ Universal beams (shown in yellow) without plating.

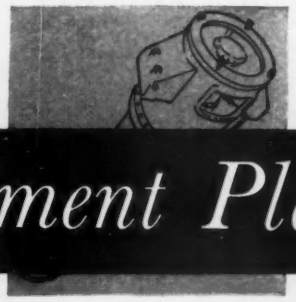


The photograph of the Catterick bridge (shown at right) by courtesy of R. Sawtell, Esq., A.M.I.C.E., County Surveyor, North Riding, Yorkshire C.C.

EARLY DELIVERY OF THE FULL RANGE OF SECTIONS

DORMAN LONG

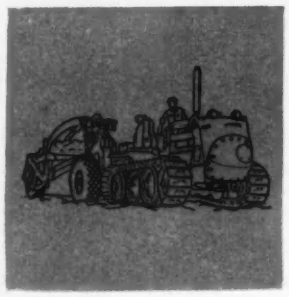
ENGINEERING WITH A BACKGROUND



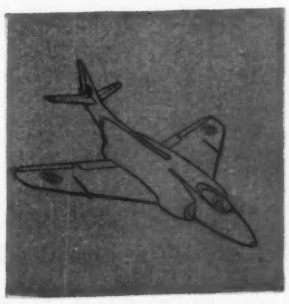
Cement Plant

In the design of machinery to withstand the arduous operating conditions met with in Cement Plants, Vickers-Armstrongs can draw on an outstanding background of engineering achievement. History-making aircraft like the Viscount and Vanguard . . . fast ocean liners such as the new Canadian Pacific 'Empress of England' and super-tankers like the 'Spyros Niarchos' . . . these are headline news. Yet, in their own fields, hundreds of lesser-known products of Vickers-Armstrongs are equally important. Whether complex or simple, each shares the same background of outstanding design and sound construction; each solves critical engineering problems.

Eastwoods Ltd., Barrington Works.



For many years Vickers-Armstrongs have specialised in the design and manufacture of efficient and dependable Cement Plant. For machinery designed to operate continuously for months on end, under arduous conditions, robust and ample construction is essential. In Vickers-Armstrongs' designs, all parts are liberally rated for long working life and minimum maintenance. Equipment on any scale is designed and built for both wet and dry process plants, and includes kilns, mills, crushers, mixers, rolls, feeders, coolers, dryers and the manufacture of cement and raw meal pumping plant. Complete installations and individual machines are now in successful operation all over the world.



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Some machines start out by packing enormous power into a small and often hot space, and there — as in some of the finest jet engines in the world — you will find FBC 'Specials', often running at fantastic speeds.

Other machines in the course of time get 'hotted up' to give far greater power or output — yet it is seldom that the original design has the space to take bigger bearings.

Here again FBC 'Specials' are saving the situation — for it is amazing what exacting duties can be carried out by the right kind of bearing, when one is really 'up against it' and enlists the aid of the right people.

Our engineers — to whom, of course, we have just referred — will always assist in the design and manufacture of 'Specials' to suit customers' problems.

FISCHER BEARINGS COMPANY LTD., WOLVERHAMPTON

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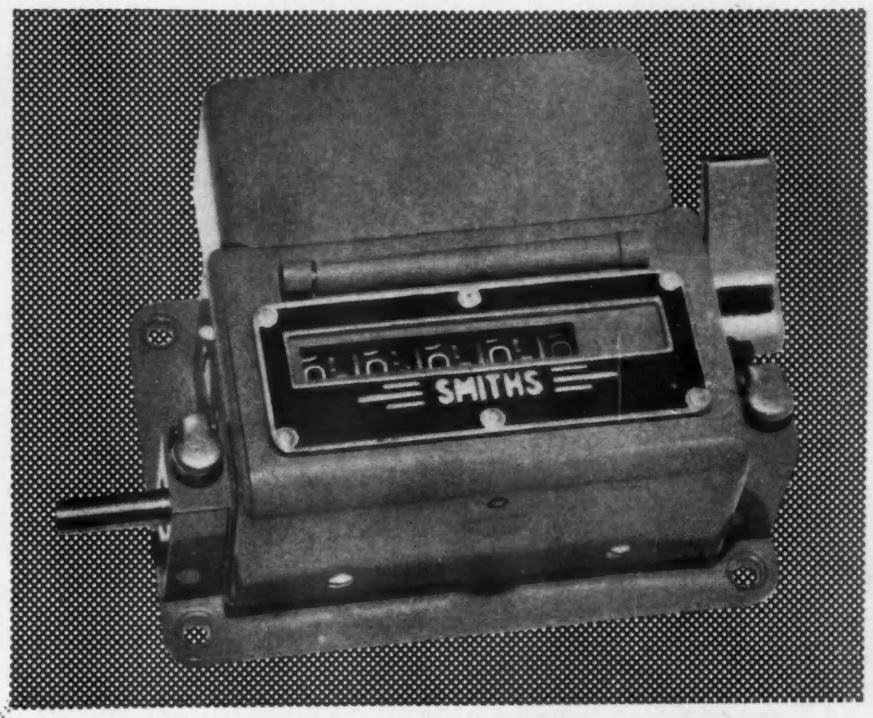
Predetermined Counters

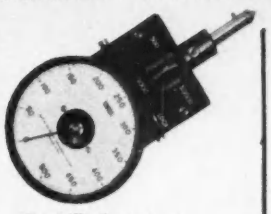
For indicating a pre-set number between 1 and 99,999.

This instrument has been introduced to provide a form of control capable of eliminating losses caused by over- or under-production, particularly on applications requiring a precise and repetitive length or number of units—lengths of cloth, coil windings, packaging and batching machines, for example.



Specification

Body:	Die-cast alloy, reasonably dust- and dirt-proof.
Counter:	White on black figures.
Speed of Count:	4,000 counts/min. Maximum Shaft Speed: 5,000 r.p.m.
Drive:	R.H. or L.H., plain shaft or flex attachment.
Rotation:	Top going or top coming.
Micro Switch:	Supplied in wide choice of agreed manufacturer/client ratings.
Total Weight:	With flex attachment, 2 lb.; plain shaft, 1 lb. 15 oz.



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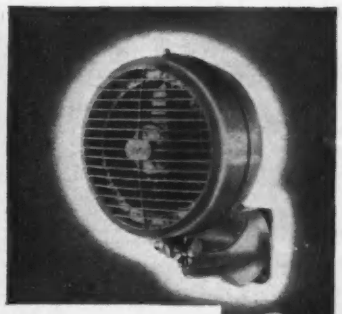

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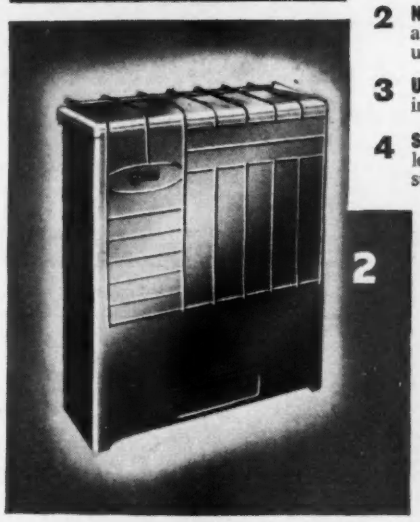
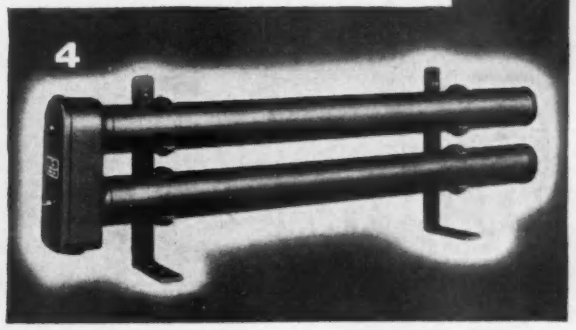
4 **STANDARD TUBULAR HEATERS**—Available in various lengths up to 4-way banks. Flameproof models also supplied.





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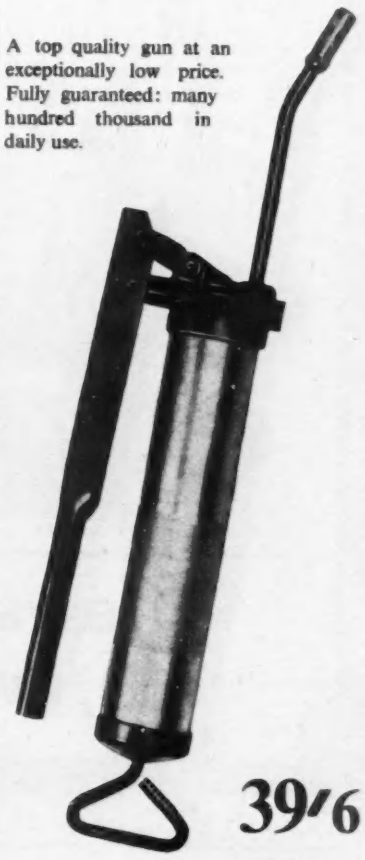

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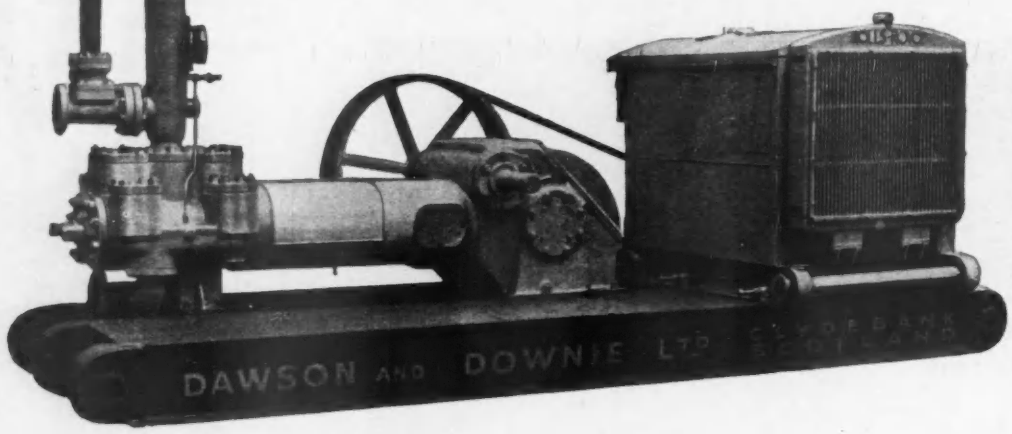

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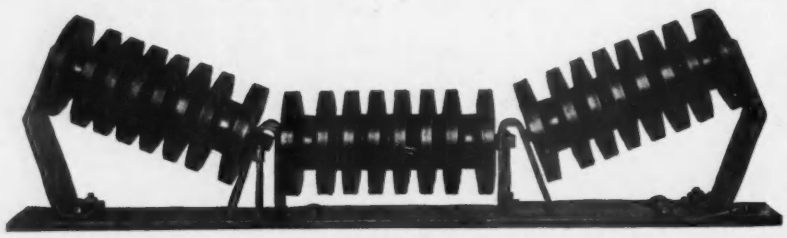

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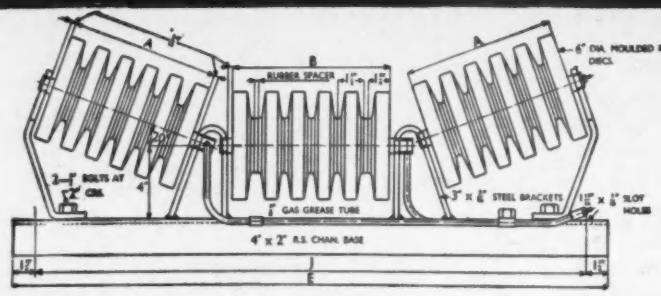
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2" GAS GREASE TUBE
3" x ¼" STEEL BRACKETS
1½" x ⅝" SLOT HOLE
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14" "	9"	6"	24"	21"
15" "	9"	7"	25"	22½"
18" "	9"	8"	28"	25½"
20" "	6½"	7"	28"	25½"
24" "	7½"	7"	30"	27½"
24" "	7½"	9"	32"	29½"
24" "	8½"	9"	34"	31½"
30" "	9"	10"	38"	35½"
30" "	10½"	10½"	40"	37½"
36" "	12½"	12½"	46"	43½"
42" "	15"	15"	52"	49½"
48" "	17"	17"	58"	55½"

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2, 3, and 5 Roll Standard Troughing Idlers. Flat and Return Belt Idlers. Rubber Disc type Return Idlers. Adjustable Take-Up Units for all duties. Mild Steel fabricated Conveyor Drums of any size AND COMPLETE CONVEYOR INSTALLATIONS.

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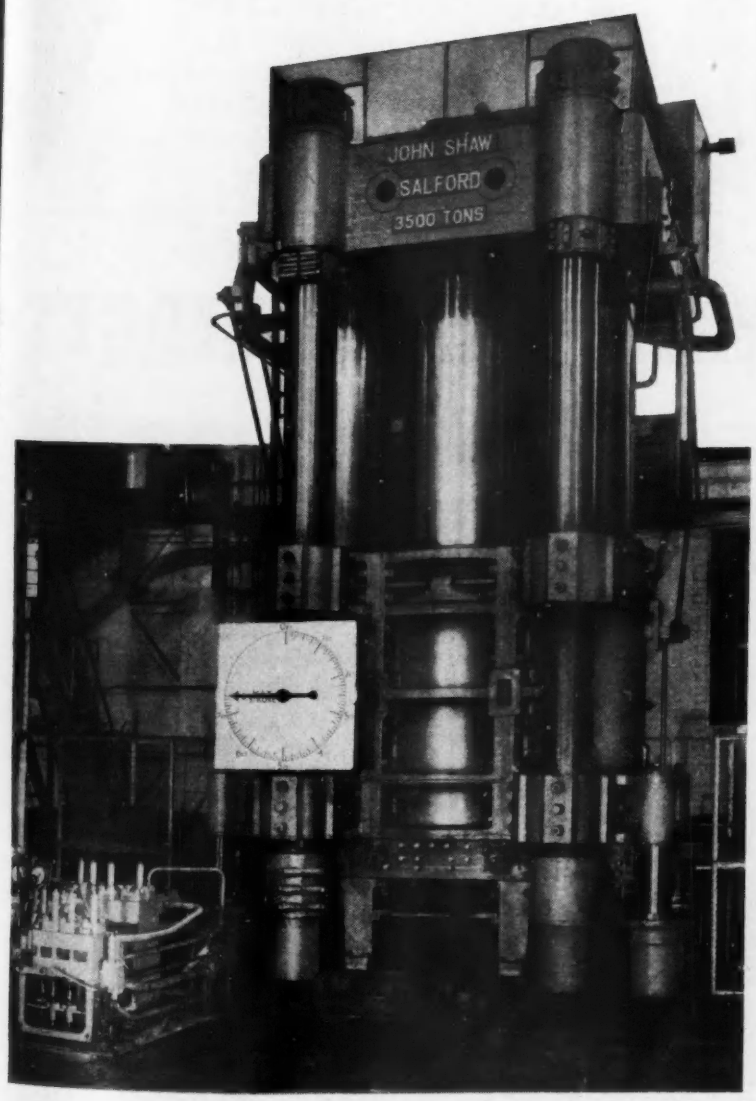

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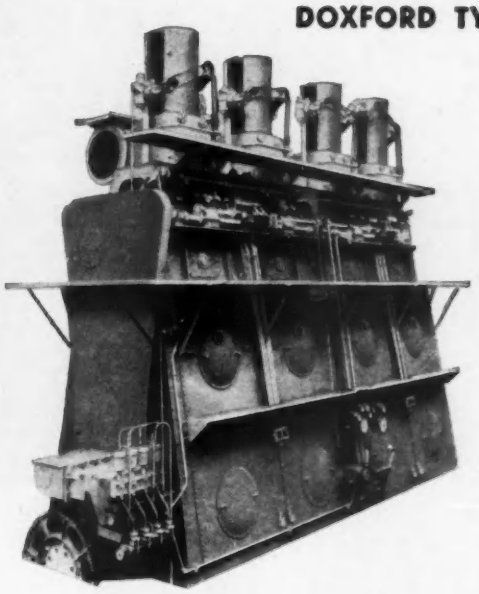
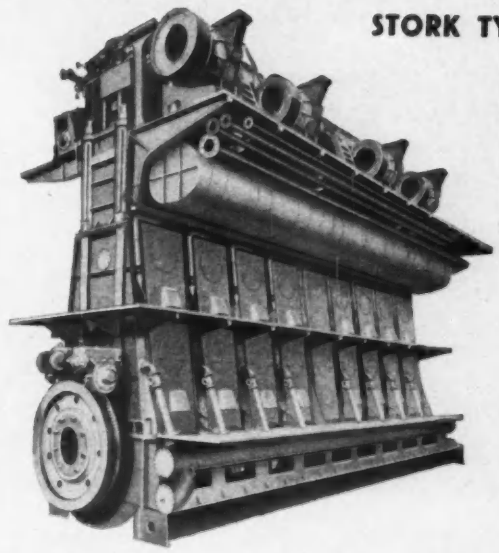
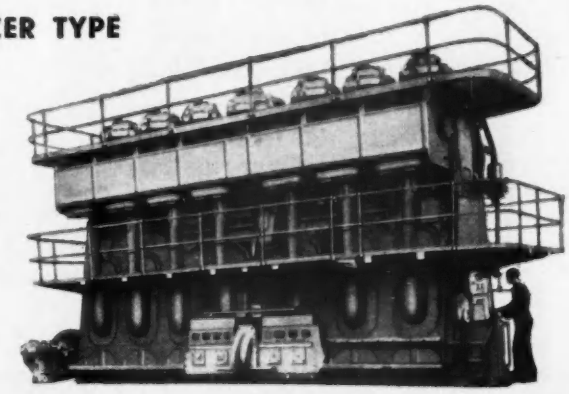


STORK TYPE



SULZER TYPE



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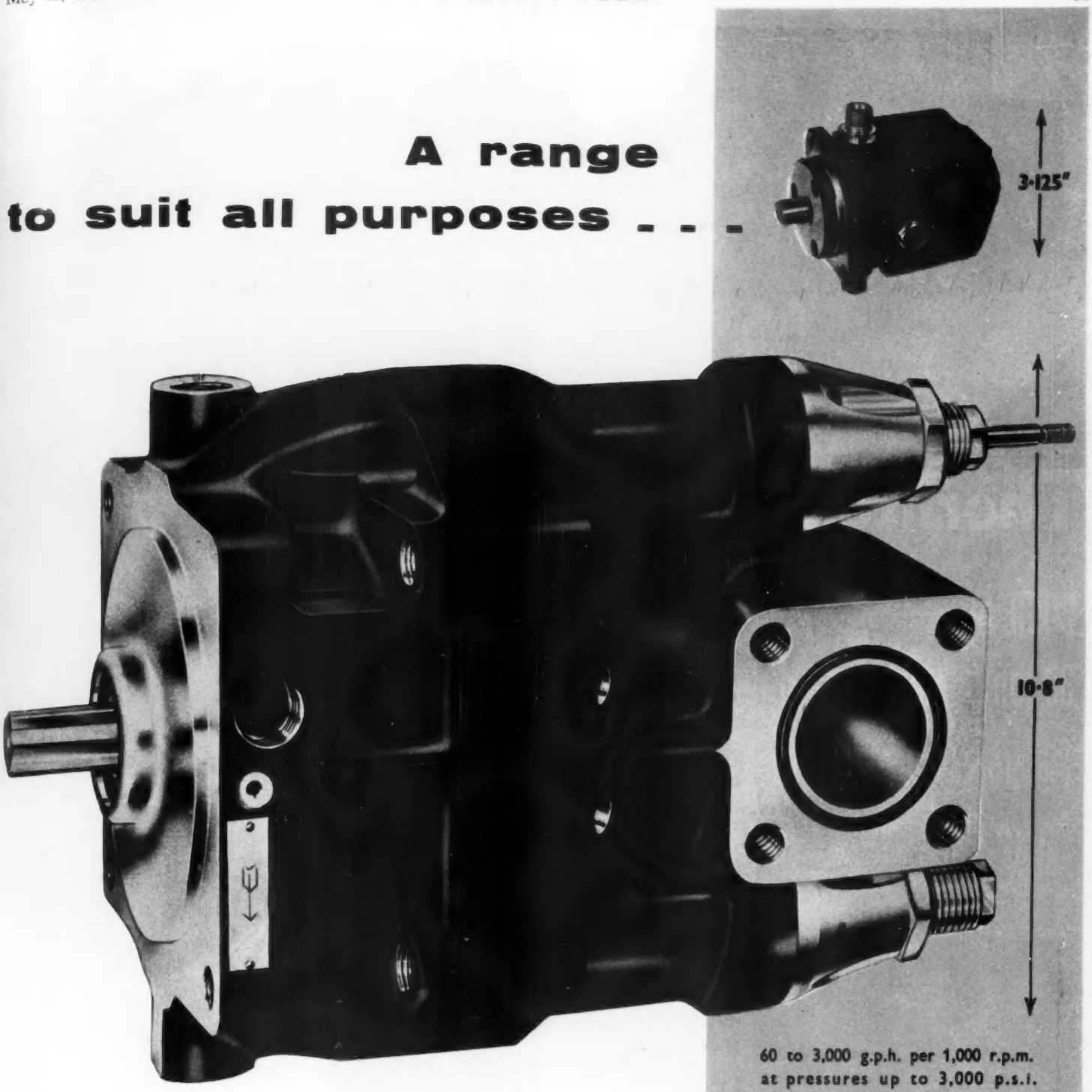

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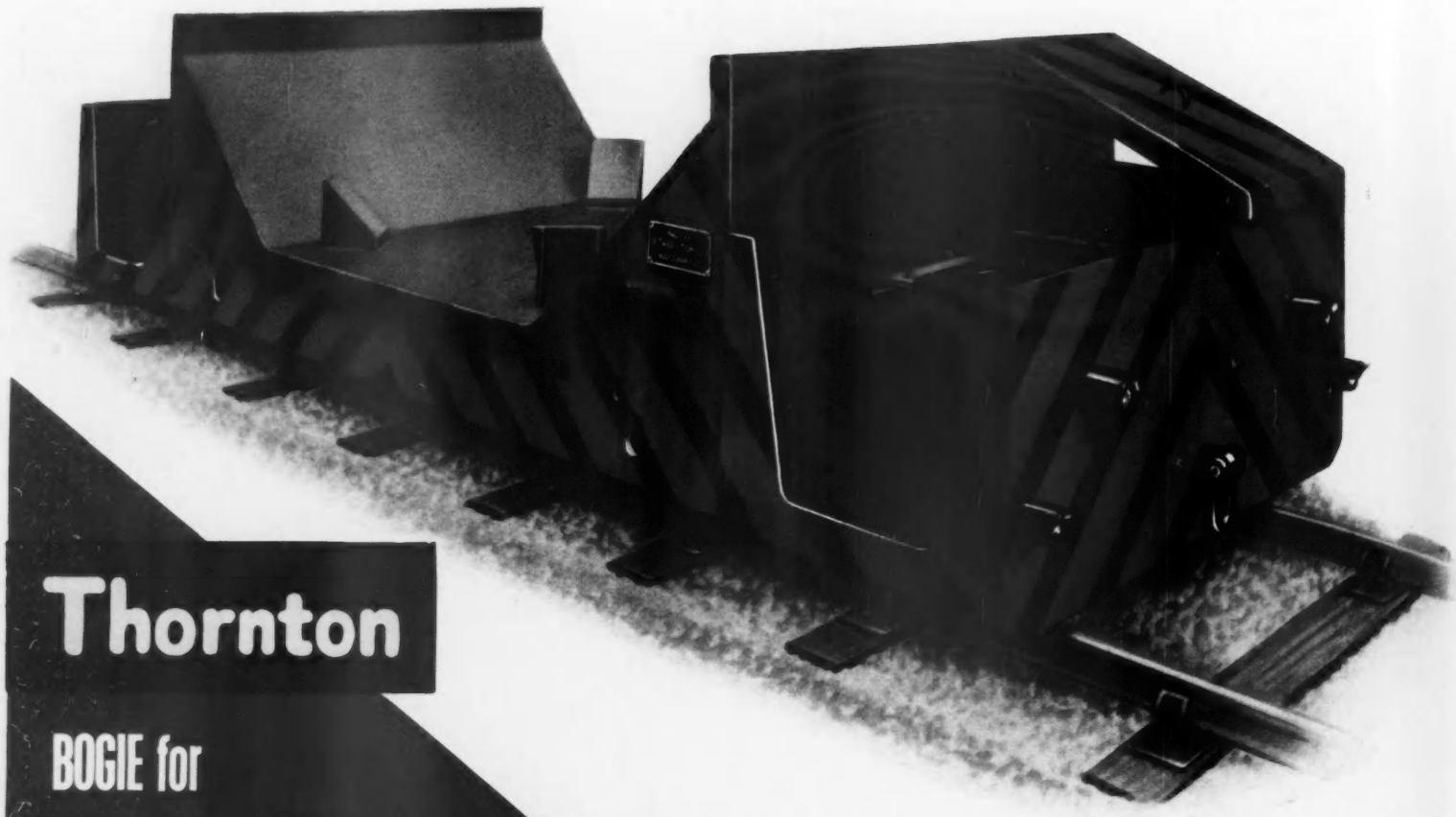

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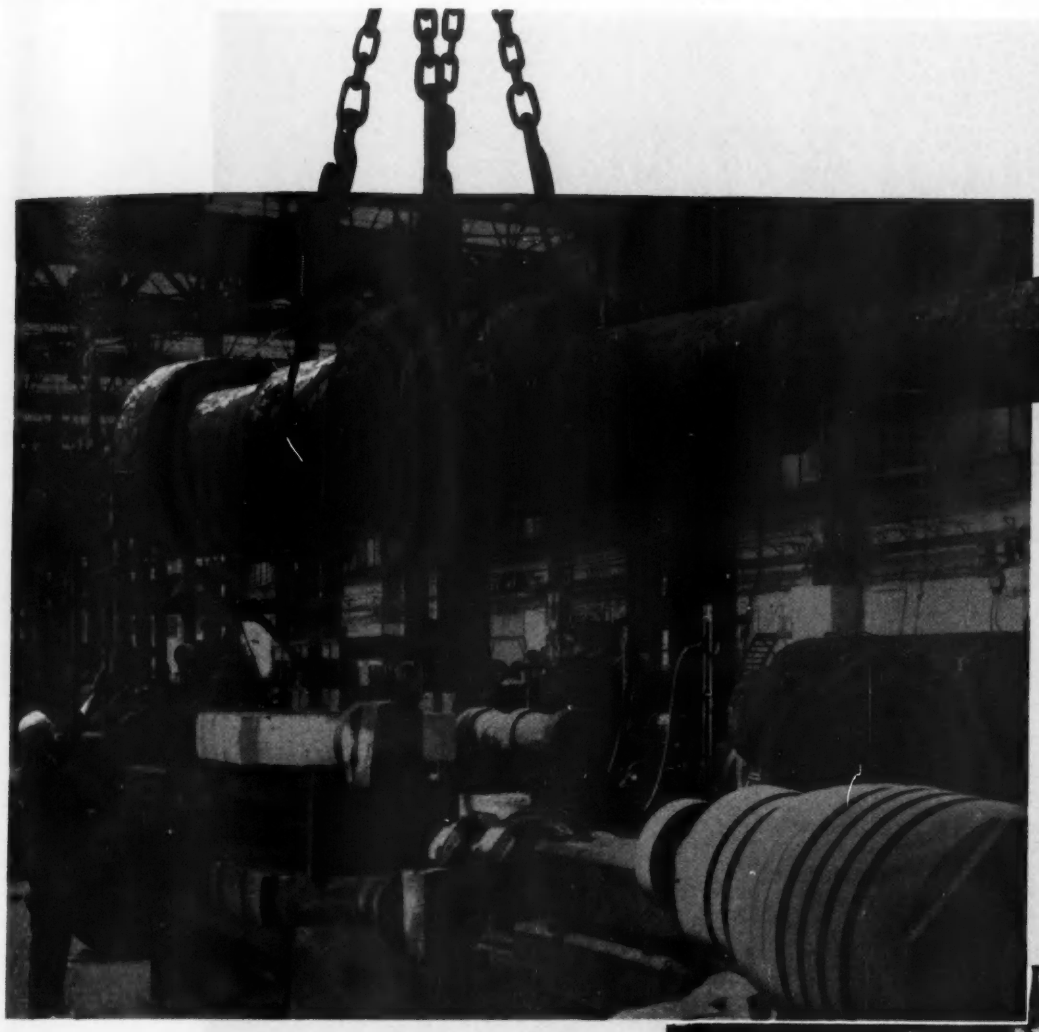

Main Shaft for Bhakra Power Station, India, supplied to the order of Metropolitan-Vickers Electrical Co. Ltd.

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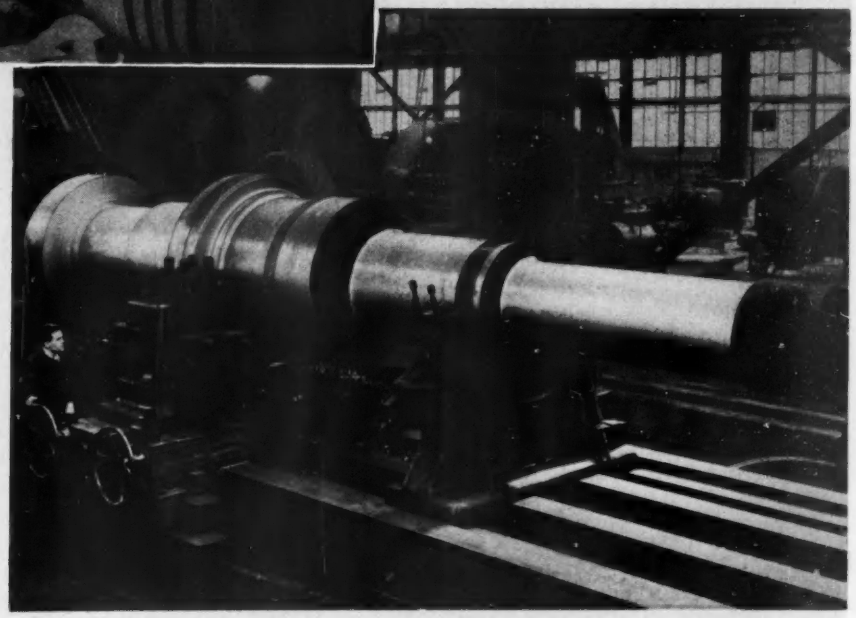

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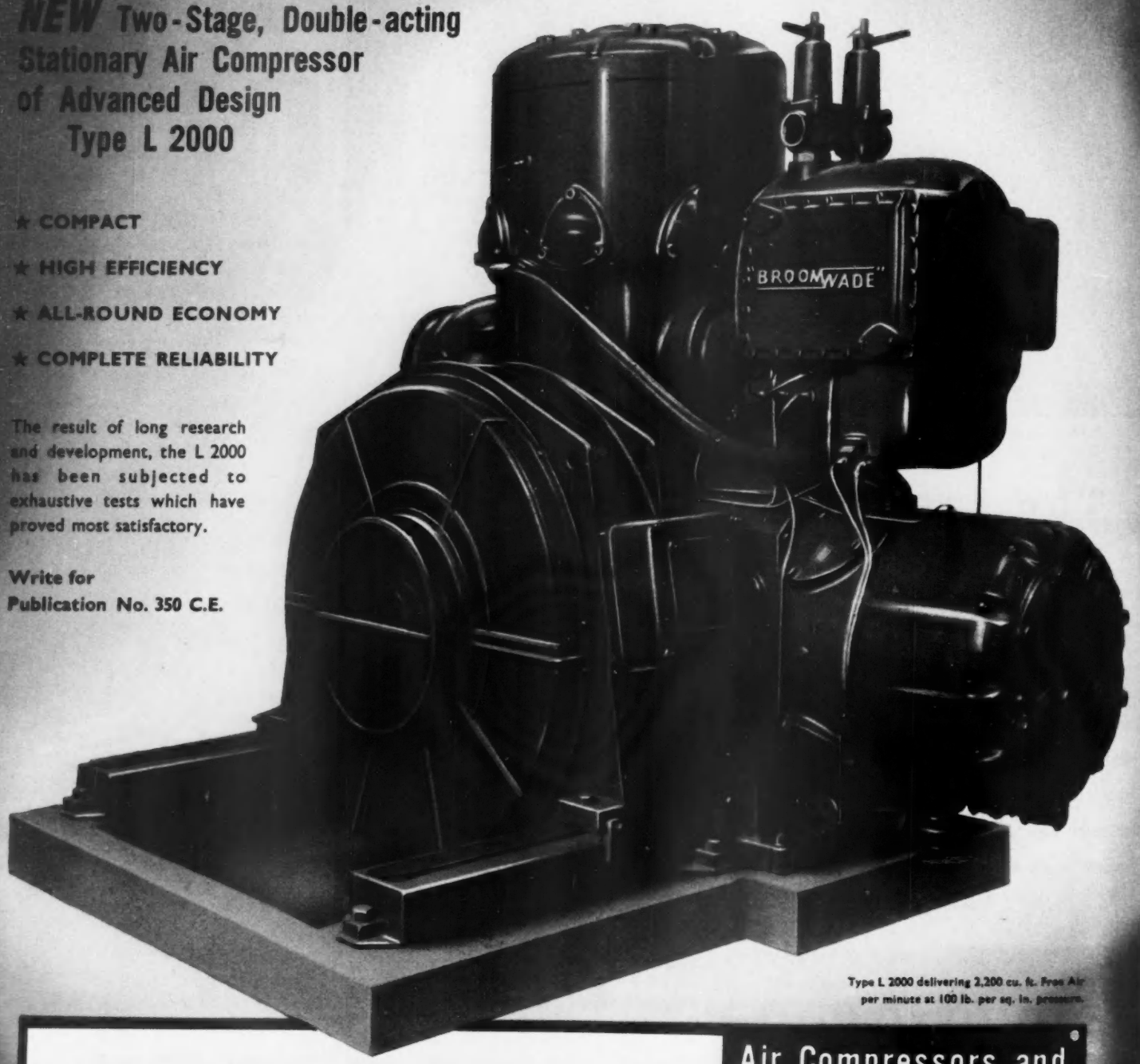

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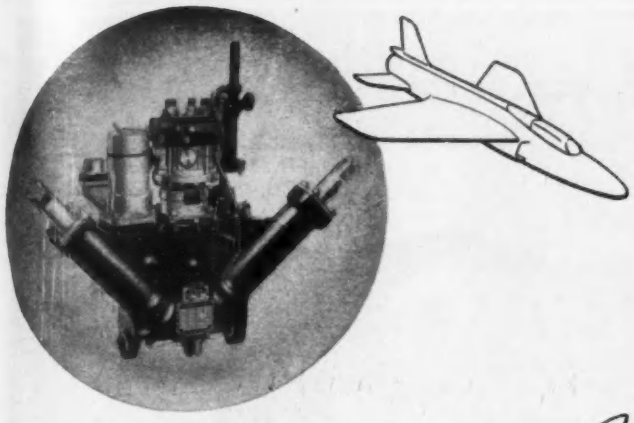

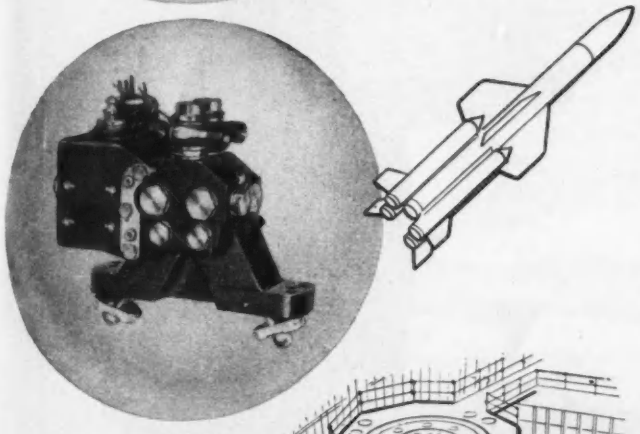

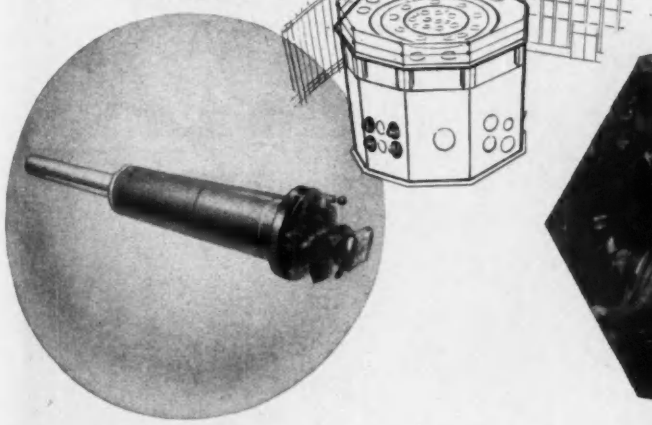

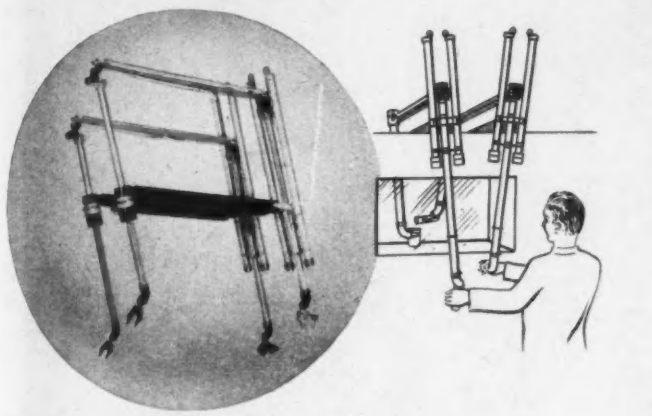

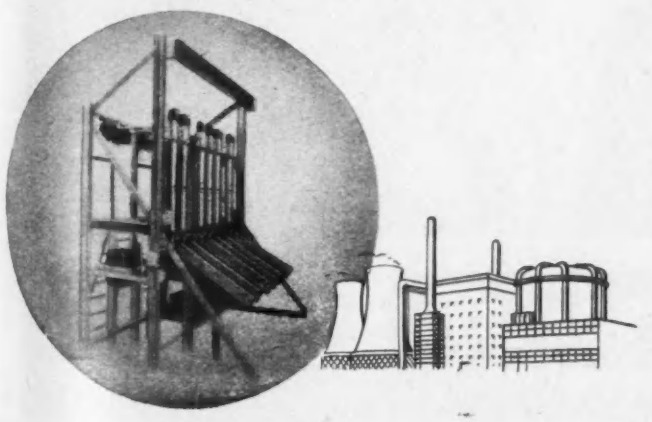

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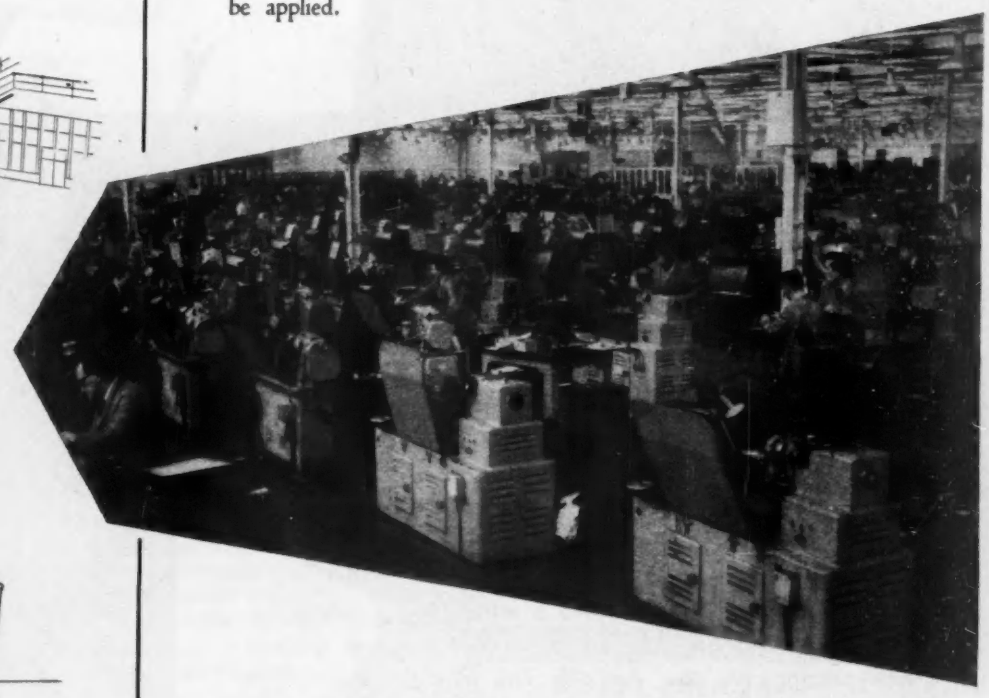

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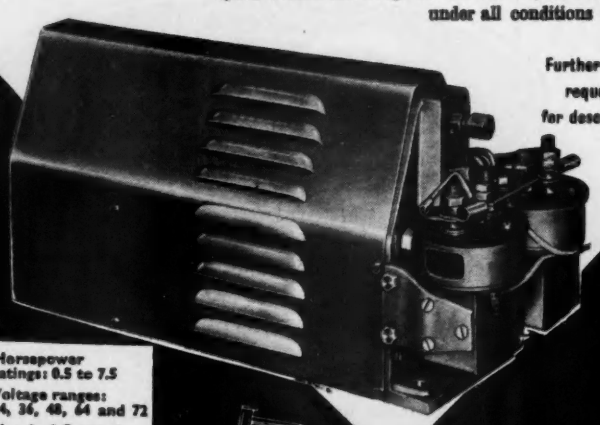

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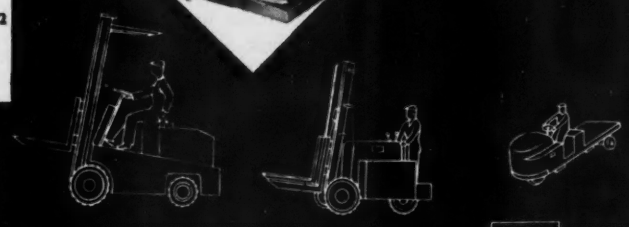

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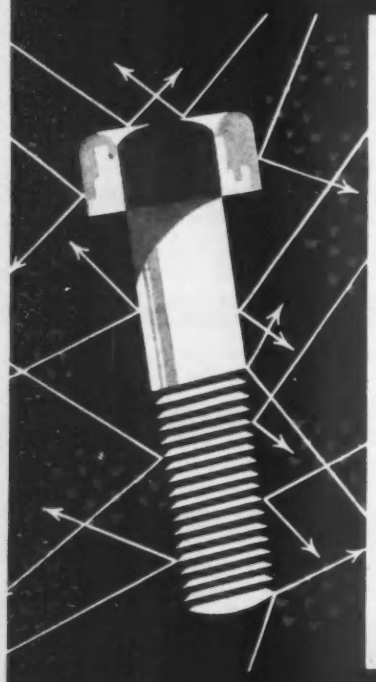

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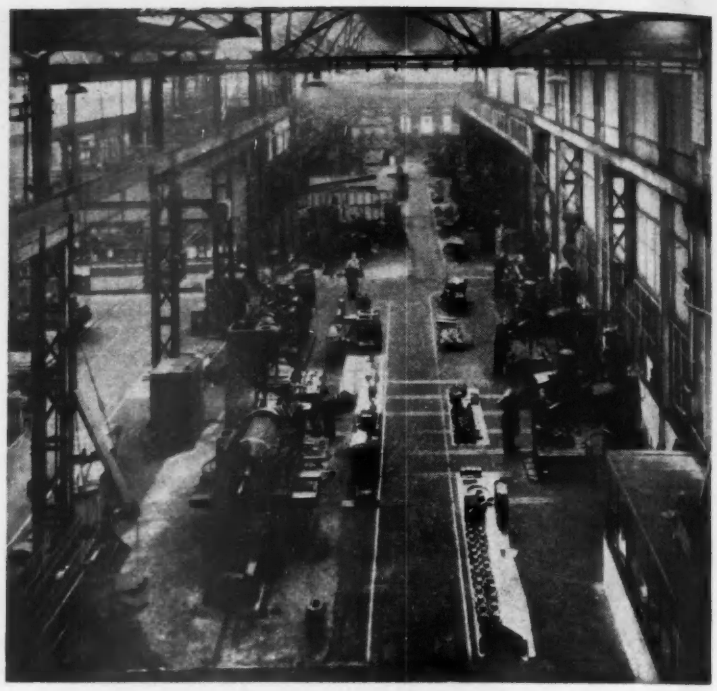

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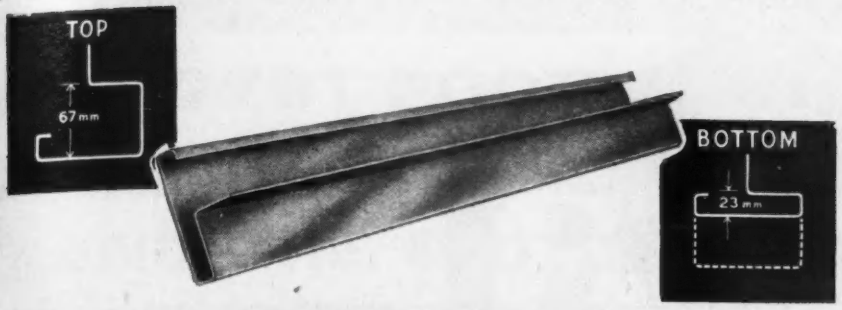

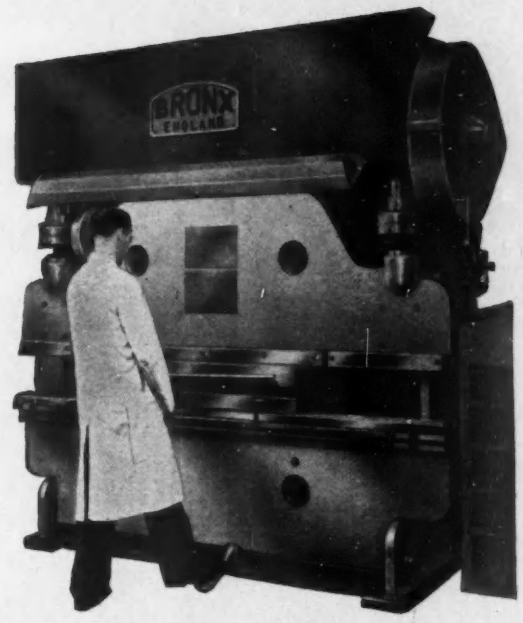

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PRESS BRAKES and Press Brake Tools

Photograph shows a 40 ton Bronx Press Brake, at Messrs. Rotaprint Ltd., Honeypot Lane, Hendon, N.W.9.

The Press is shown producing tapered stand support legs, in a cycle time of 50 seconds by one operator, and the locations are obtained by a series of flip stops.

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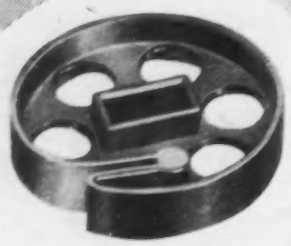

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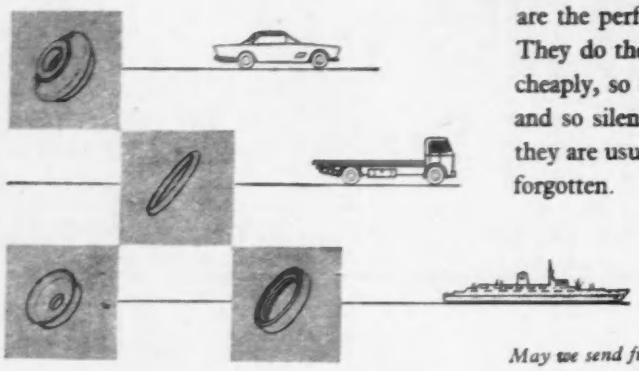

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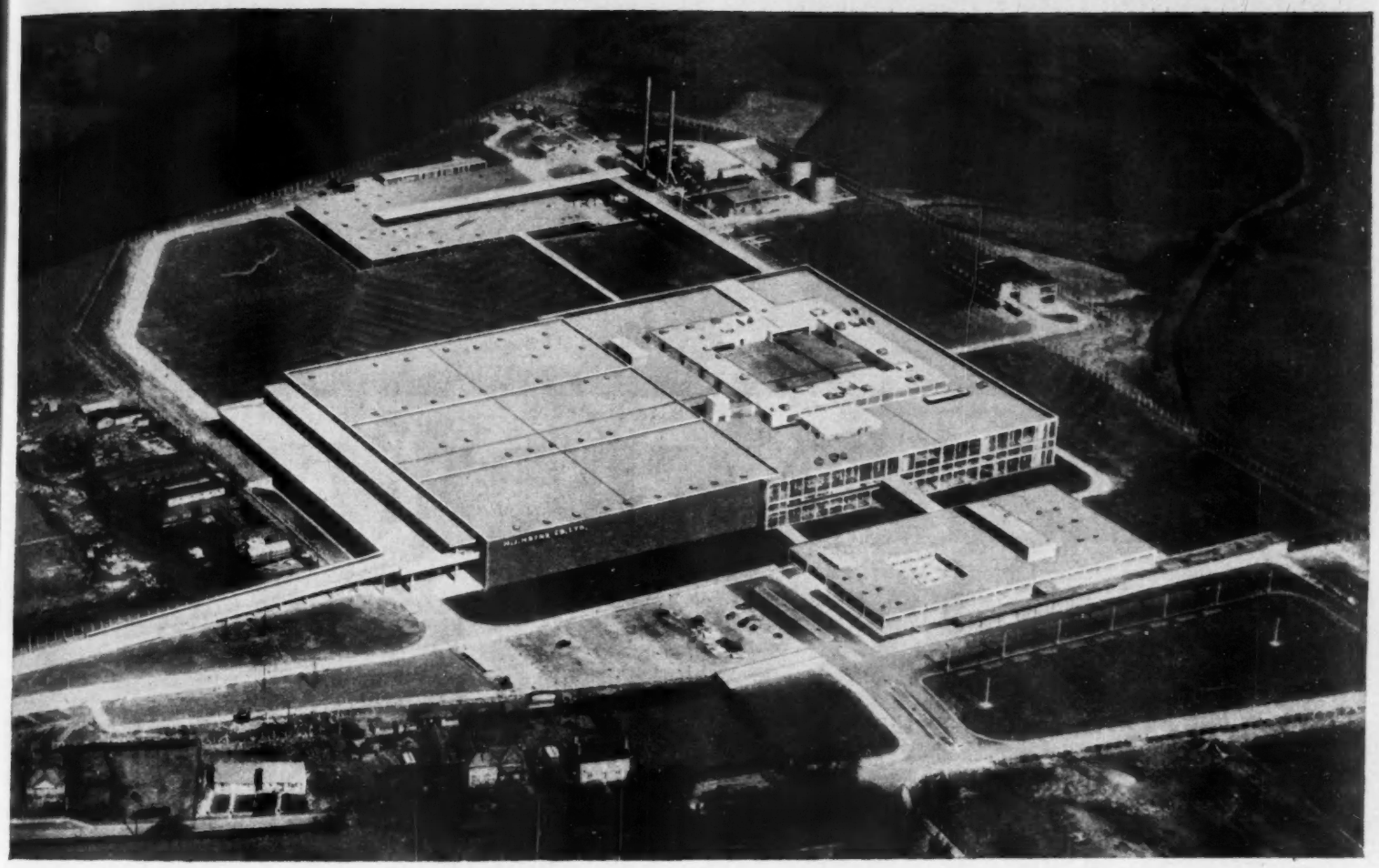

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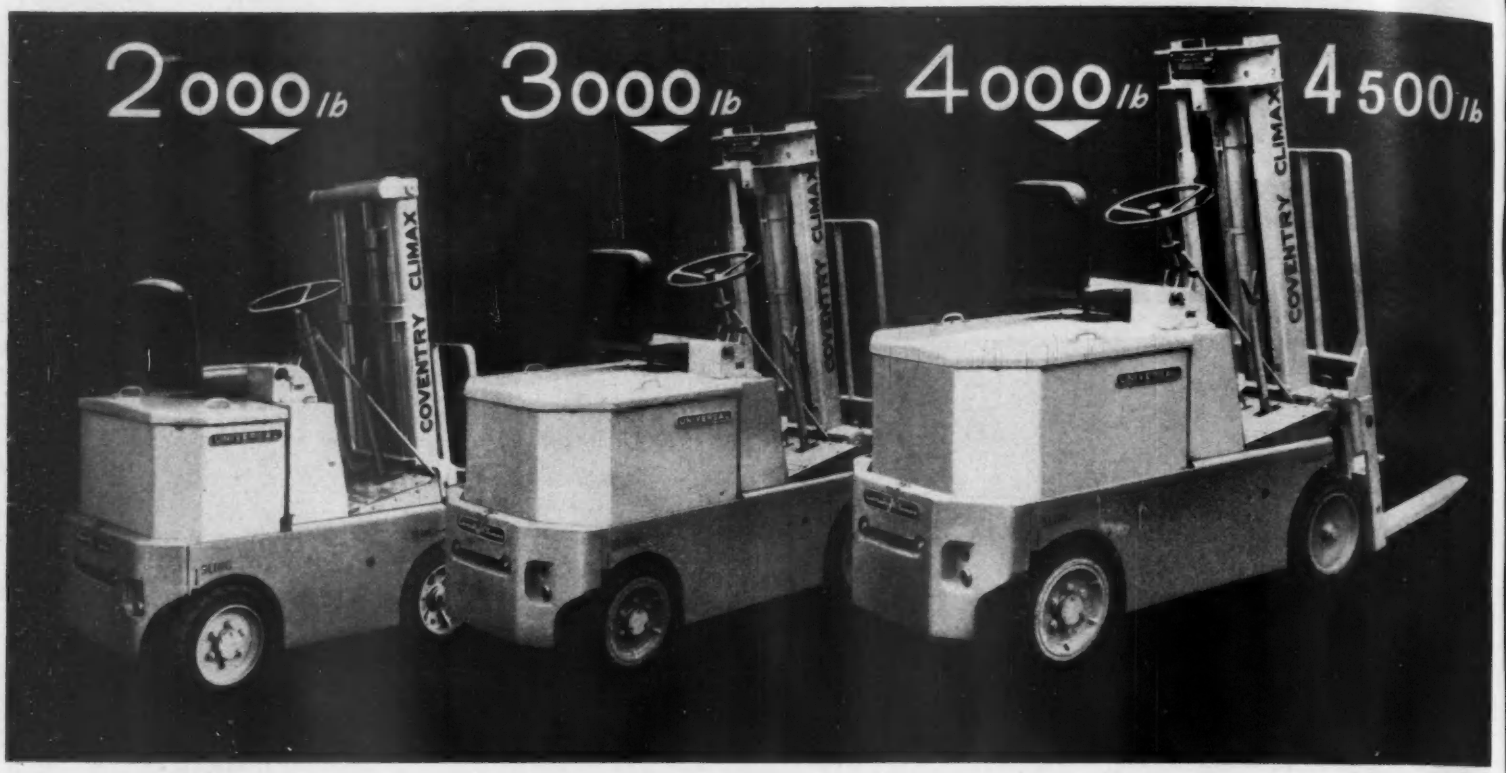

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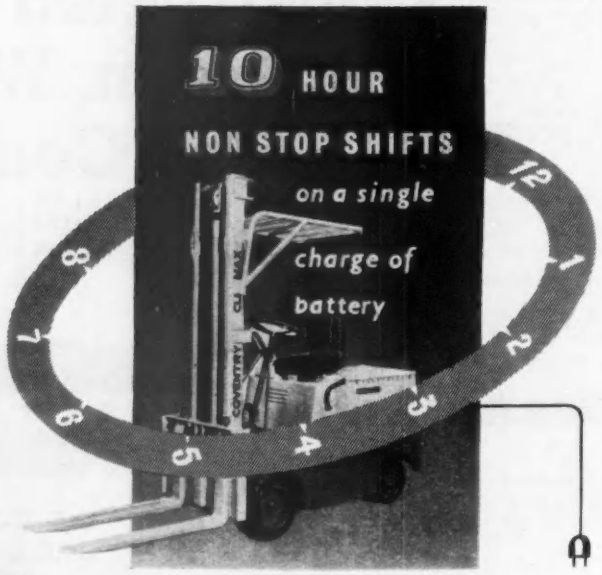

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THE ENGINEER

No. 5391 MAY 22, 1959 VOL. 207

VIGOUR IN MACHINE TOOLS

Year by year we get the impression that the Machine Tool Trades Association is changing its character. Its annual report for 1958, adopted at the annual general meeting of the Association in March and distributed to members, confirms that impression. Though in the past the Association indignantly rebutted most of the criticism which was showered on the industry, it has clearly taken some of it to heart. Perhaps also new personalities have come to the fore to influence its activities. Certainly as much positive action seems to have been taken in the year under review as formerly occurred in a decade or so. That is not merely our view, which the Association might regard as prejudiced since we have been amongst its critics. It is also the opinion of the Association's own President. In presenting the report he remarked, for example, that the past twelve months had marked a turning point in the history of the trade association, for they had witnessed the translation of high resolve into direct, positive action. He was also able to claim that the members now appreciated that the facilities provided by the Association amounted to one of the most potent weapons disposed of by the machine tool trade of this country for defence against nationalisation proposals, and for purposes of trade and business, especially export trade.

But the militancy of the Association in rebutting, for example, nationalisation proposals, would be useless if there was not also growing evidence that machine tool makers are losing their former irritating complacency about the state of their industry, are actively becoming more self-critical, and are energetically setting out to rectify faults. The President was able to refer to a changing attitude of member firms towards the public and a continuation, since the publication last year of a document designed to give the public real information about the industry, of the policy of throwing open its doors to all visitors. That self-criticism has become active is indicated by the fact that two representatives of the D.S.I.R. have been making a tour of the manufacturing sector to study aspects of development work ; and that the Association has itself conducted a sample investigation into the research and development work being done by member firms. Clearly it has been appreciated that it is not enough for an industry to defend itself from attack by appealing to past history. It must show, in addition, that it is looking vigorously towards the future.

Perhaps the event of 1958 that most startled the critics was the creation by the M.T.T.A., in conjunction with the Manchester College of Technology, of Design Scholarships, which will ensure that in future there will be a steady flow of young men trained in design into the industry. No more effective action could have been taken to answer critics who have declared British machine tool makers too conservative and insufficiently interested in advanced design. For measures of this kind will do far more to enlist public sympathy than could be achieved by a contentious and spasmodic advertising campaign. Other activities mentioned in the report suggest that the Association is becoming equally energetic in other fields, particularly those affecting trade. Increasingly, it appears, the Association is being called upon to approach the problems of certain markets on a national level, securing for the individual member the full benefits of the collective approach, with all its attendant publicity. This activity is exemplified by the sending recently of a mission to Spain. For too long the public has been led to believe, not without a substratum of truth, that British machine tool makers are complacent, conservative, and lacking in energy and initiative. But if the Association continues to act with the kind of energy it has shown recently that kind of criticism will no longer be valid.

CONTRACTORS AND TRANSPORT

It is really rather remarkable that until Mr. Watkinson was appointed to that office, no post-war Minister of Transport was made a member of the Cabinet. Just how remarkable was made clear when Mr. Watkinson proposed the toast of the Federation of Civil Engineering Contractors at the annual dinner of that body on Tuesday of last week. For Mr. Watkinson referred to almost all the facets of his work and, incidentally thereby, revealed how widespread are the activities for which his Ministry carries responsibility. About the air he claimed that his Ministry was learning a lesson from the roads. There had been a lack of foresight in successive road programmes and what a boon it would be had roadworks under construction now been commissioned twenty-five years ago ! That kind of mistake, he claimed, was not being repeated in the air. Great importance was attached to the development of new systems of control, better airports, and so on. Gatwick airport, he predicted, would be full to bursting long before many people expect. The Central Terminal Area at London airport remained to be completed by the building of new hard-standing areas and there was the long-range terminal building still to be erected. In addition British European Airways was being encouraged to evaluate the " Rotodyne " as a means of carrying fifty or sixty passengers from city-centre to city-centre. There the question of reducing noise arose. It arose even more acutely over jet aircraft. Quite forthrightly Mr. Watkinson declared, " I have not yet seen any supersonic passenger project which does not appear to depend on a degree of thrust which, despite all the blast walls and silencing devices which your industry can produce on the ground, will need a vast deal more silencing on the airframe itself before it can be regarded as house-trained enough by my Ministry to go into civil airline service."

Mr. Watkinson has spoken so often about the road building programme that there is no need to report here more than his view that the country should first concentrate on building a major framework of new motor roads ; and that he is clearly attracted by the idea of

building new roads over existing roads and railways in urban areas. It was pleasing to hear him admitting that an expenditure of £60,000,000 per year on new construction and £140 million *in toto* might be not enough ; and better still, perhaps, to hear him say that no Minister of Transport should ever be satisfied. Especially if there is to be adequate expenditure on urban roads, substantially larger sums will need to be extracted from the Treasury than even Mr. Watkinson as a member of the Cabinet has been able to get. It was only when he came to refer to railways that he seemed to us to slip up a little. It may well be true, as he claimed, that no other system could haul some 3,500,000 passengers a day as this country's railways do ; but it remains to be proved that " no other system can offer such quick and cheap transit for heavy loads once British Railways have developed the door-to-door container service which is already within their grasp." In replying to the Toast Mr. Douglas, president of the Federation, assured the Minister of the civil engineering contracting industry's whole-hearted co-operation in carrying out his road programme. He added, significantly, that the industry could, if given the opportunity, " bite off considerably more than it had so far been given to chew without the slightest risk of suffering from constructional indigestion."

FUTURE OF PROFESSIONAL METALLURGY

The Institution of Metallurgists, whose annual general meeting was held on May 12, began to unite, and to represent, the professional metallurgists of this country in 1945, and since then it has been led by a dozen vigorous and progressive presidents, with experience in industry, the universities and the scientific Civil Service. The well-conducted professional examinations, which it helps to arrange, attract nearly a thousand candidates each year, and its membership of qualified Fellows, Associates and Licentiates now totals nearly four thousand. Recently a comprehensive revision of the requirements and syllabuses for its Licentiateship and Associateship examinations has been completed, after much consultation with the Ministry of Education and other professional bodies and institutions. The Institution of Metallurgists owes very much indeed to the help it received from the Iron and Steel Institute and the Institute of Metals in its formation and early years ; in fact one may recall that Mr. K. Headlam-Morley, the widely known Secretary of the former, also served as Secretary of the Institution of Metallurgists for the first three years of its life.

The two older institutes have much larger memberships and possess well established secretariats and an invaluable " Joint Library " ; through the years they have each earned worldwide respect. Their efforts towards international co-operation and understanding have been highly successful ; they have many foreign members and both of these older Institutes have organised for their members numerous highly successful, enjoyable and instructive visits to friendly foreign countries. Little over a year ago the President of the Iron and Steel Institute was A. H. Ingen-Housz, a distinguished Dutchman, and the President of the Institute of Metals was a very famous wartime leader, Lord Tedder. Nevertheless these two older institutes do not conduct any qualifying examinations, such as one is accustomed to in the senior engineering institutions. Hence it comes that the Institution of Metallurgists fills this gap and provides, with the Ordinary and Higher National Certificates in Metallurgy, an encouraging stairway of courses leading to examinations, by which a young metallurgist, who has not the benefit of a university degree, may raise himself later in life by his own efforts into the ranks of those who possess accepted professional qualifications.

Younger metallurgists now dream of an all-embracing Metallurgical Institution, which may come into existence at some future date ; as in all dreams much of the detail cannot be clearly defined. Where, for example, one will ask, should the all-embracing cease ? Are the Institution of Mining and Metallurgy, the Institute of British Foundrymen and the Institute of Metal Finishing not as essential to many metallurgists as the Iron and Steel Institute and the Institute of Metals ? Whatever the future holds, and clearly no unilateral move should be anticipated, the metallurgical professional bodies have all notably strengthened their memberships and increased their useful activities during the last decade. They render very valuable services to industry and to people in general. But one little problem remains unsolved; for no one can be sure how his hearers expect him to pronounce the word Metallurgist. The schism between the Me*tal*-*l*urgists and the Meta*llurg*ists still remains. No doubt some third pronunciation will be discovered by the younger men and Metalergists will study Metalergy !

REDUCTIO AD ABSURDUM

There is an ancient injunction, current some twenty-four centuries ago, which bids us *enquire and make search and ask diligently*. If more attention were paid to it to-day we might not behold the spectacle of strikes such as some of those which have lately involved stoppages due to private fights between trade unions. Surely it is an absurdity that in one recent case upwards of 3500 workers should have to be sent home because members of one trade union refuse to work with a member of another trade union. The stupidity of such procedure is enhanced by the reported statement of the district organiser of one of the unions concerned that " We are determined, this time, to fight it out to the bitter end. The difficulties which have arisen between the unions must be settled once and for all."

Surely collaboration in the promotion and maintenance of gainful employment should be a major objective of all trade unionists on the grounds not only of personal but of national welfare. The turning of factories into arenas for inter-union slogging matches is an exhibition of sheer unreason, particularly when we remember, as we should, that repetition of this sort of thing could rapidly involve the ruin of a country which, without punctual export of its manufactures, cannot remain solvent. It is manifestly vital to the reputation of the trade union movement that it should take steps to render such performances impossible. Fortunately, the movement is not without its quota of experienced leaders. At the 89th Trade Union Congress held at Blackpool in 1957 Sir Thomas Williamson, the President, did not refrain from attacking abuses : " To safeguard unity and democracy in the movement and maintain our prestige in the community, we must," he said, " condemn and restrain those who organise unofficial movements and unofficial strikes. . . . There is no virtue in striking when there is no real need to do so. Every dispute must end in a settlement, and we should work for a solution before a stoppage takes place, even though it may call for patience and forbearance often in the face of provocation." Another speaker at Blackpool — the General Secretary of the Engineer Surveyors' Union—is reported as having described inter-union strife as possibly the greatest evil and enemy of the trade union movement. Not many months ago, Mr. Alfred Robens, M.P., the Labour Party " Shadow Minister of Labour," described strikes in the second half of the twentieth century as an " anachronism." " They are," he said, " a blunt instru-

ment with all the dangerous propensities of a boomerang." What the strike does to-day " is to hold up orders. It does let down those customers who are depending on delivery of goods at a certain time. It causes investors to be a little chary of investing in any industry which has a long black record of strikes." Mr. Robens concluded his address—which was to members of the Industrial Co-partnership Association—with the following wise words : " It is our task on both sides of industry to bring about a climate in which disputes, which are bound to arise day by day in industry, can be properly, sensibly, and intelligently settled round a table rather than by an industrial war." In his Stafford Cripps Memorial Lecture Sir John Woods—former Permanent Secretary to the wartime Ministry of Production—referred to the damage caused by restrictive practices. He is reported as having declared that " The pursuit of group interests to-day is not enough. We are of necessity the greatest importing country in the world. We are therefore dependent on our current efforts. The reserves are notoriously low. We are a debtor country . . . and we have to pay due attention to that fact."

It is certainly high time that talk about *fighting* it out " to the bitter end " should cease. The way to avoid a " bitter end " is by *thinking* it out. What can be a more bitter end than the multiplication of trade union private fights involving the equivalent of lock-outs imposed by trade union irrationality ? Not to be overlooked in this connection is the work of an eminent engineer born 103 years ago. His name was Frederick Winslow Taylor and he devoted the greater part of his life to the evolution of methods whereby workshop efficiency could be promoted and profitable manufacture ensured without creating antagonism between management and men. After serving his apprenticeship as a pattern maker, Taylor worked as a labourer in the Midvale Steel Company's plant at Philadelphia. Rising to be chief engineer he ended by becoming the " Father of Scientific Management " and we read that in none of the works wherein he operated was there ever a strike. F. W. Taylor, were he with us again to-day, would find it difficult to believe that half a century after the publication of his exposition of shop management, thousands of men should be sent home from a single factory because of a difference of opinion between two trade unions as to who should bore certain holes, or who should chalk lines on a steel plate. Everyone of us is either a peace maker or a trouble maker, though providentially, the peace makers are by far the more numerous. Let them take such concerted action as shall prevent the recurrence of stoppages of this kind. It is, of course, true —though the lay public is often given a reverse impression —that labour relations in this country can bear comparison with those anywhere else in the world. Such events as those of which we write are fortunately very few indeed. American and other foreign concerns operating factories here have, for example, few complaints. But nothing unfortunately creates a worse impression abroad than some stupid inter-union dispute about some minor detail of a manufacturing process.

EDUCATION AND CAREERS EXHIBITION

On May 26 there will open at Olympia, in London, the National Education and Careers Exhibition. It is the first time this Exhibition, organised by the National Union of Teachers, has been held. The Exhibition will have relevance only to the State system of education in England and Wales. The co-operation of other bodies has been secured, including the Federation of British Industries, the British Employers' Confederation, Trades Union Congress and the Ministry. We rather gather that the major emphasis may be placed on primary and secondary education ; but substantial attention is to be given to later education. Actual classes will be shown in progress, including one of students doing experiments in control engineering, put on by a College of Advanced Technology. Experiments are also to be made with closed circuit television to establish whether or not it is likely to prove useful for educational purposes. It is believed that the value of television may particularly lie in its power to present a close-up view to a large audience. There will be lectures daily, instructional and careers films will be shown, and schools from all over the country will demonstrate their prowess in acting, dancing, music, &c., in the Exhibition theatre.

Adults, and particularly engineering adults, will be especially interested in the careers side of the Exhibition. This is to be supported by the Federation of British Industries, the nationalised industries, trade and employers associations, and individual firms, all of which will naturally stress how rewarding is a career in industry. In addition, certain ministries, the Navy, and local government, will be represented. Education in industry will be stressed by the British Iron and Steel Federation, Imperial Chemical Industries, Ltd., the Scientific Instrument Manufacturers' Association, and others. The universities are also supporting the Exhibition. The only really notable absentees are the major engineering institutions. They have gone no further than to provide pamphlets, giving information about careers in engineering, for distribution. It seems a pity. But perhaps their Charters prevent them expending money for such a purpose. The organisers would grant them no special status. If they had taken space at the Exhibition they would have had to pay for it.

The Engineer—100 Years Ago (MAY 20, 1859)

" Iron Ships of War "

" After so much discussion upon the construction of iron war vessels, it appears that Government has contracted for one of great size and great intended speed, to be used perhaps, whenever an occasion may present itself, as a steam battering ram. With 6,000 tons burden, the new iron vessel is to run at fourteen knots. Until, however, a chance is had to run down an enemy's ship, which, in the meantime, will be doing its best to keep out of the way and to disable its assailant, this great craft must be formidable chiefly for its armament. It is simply an iron man-of-war much larger than anything now built of wood.

" The advantages and disadvantages of iron as a material for fighting ships have been often discussed and are well understood. Iron plates of ordinary, and even of extraordinary, thickness are perfectly penetrable under the fire of heavy ordnance. Iron of 4½in. thickness is only shell-proof ; and an entirely shot-proof vessel is as yet unknown. Under the impact, also, of heavy shot it is even more difficult to prevent the yielding of the frames than to exclude the fire. And if iron plates of whatever thickness be perforated in action, the openings are of such a character as nearly to defy all attempts at plugging ; whilst to plank them over from the outside, as in wooden ships, is impossible. This has been fully proved in naval experience ; the Queen and other iron steamers of the Indian Navy, having been nearly destroyed under the action of the enemy's fire in the Chinese War of 1843. There has been, too, the great difficulty of fouling in the case of iron ships exposed for a long time on foreign stations, with no opportunities for going into dock. On the other hand, iron vessels have greater strength, buoyancy, and capacity, and greater durability under ordinary service than wooden ships of the same dimensions."

Nuclear Reactors for Marine Propulsion

No. II—(*Continued from page* 756, *May* 15)

Recently we published an Admiralty announcement that a number of firms and consortia had proposed designs for nuclear reactors for ships. The merits of these designs are to be assessed by a technical sub-committee of the Civil Lord's Committee. We have secured particulars of some of these designs.

De HAVILLAND HIGH-TEMPERATURE GAS-COOLED REACTOR

STUDIES made by the de Havilland Nuclear Power Group have led to a proposal which involves the use of a high-temperature gas-cooled reactor (H.T.G.C.R.). This system is still in the early stages of development but an appreciation of its potentialities is indicated by the rapidly growing interest both in this country and abroad. In this country the Atomic Energy Authority has been studying the system for some time and both loop and zero energy reactor experiments will be operating in the near future. The design of an experimental H.T.G.C. power reactor called "Dragon" is also in hand and its construction is planned for completion by the end of 1962. It is

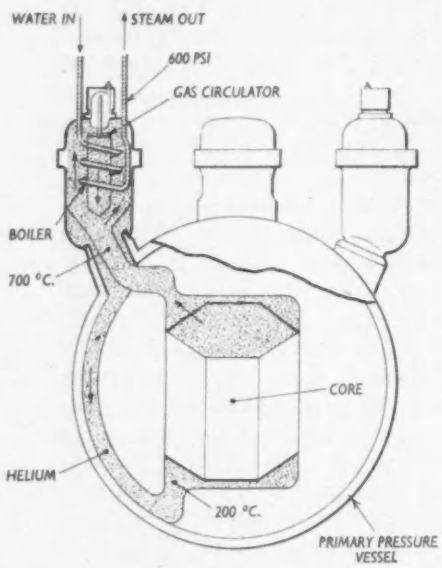


Fig. 10—Diagrammatic layout of proposed de Havilland h.t.g.c. reactor for marine propulsion

significant, also, that a number of reactors designed on similar principles are being investigated in the U.S.A., notably by General Dynamics Corporation, and in West Germany a group of companies is proposing to build a reactor of this kind.

Although the present study is primarily for a naval application, the system chosen by de Havilland's commended itself because it shows promise of being economic in operation—a factor which will determine whether or not it can be applied to merchant ships. Furthermore, if the system can meet the requirements of both naval and mercantile marine, the large effort, both technical and financial, likely to be associated with prototype construction need not be duplicated. It is believed that with the proposed system no hazard to personnel would arise from the escape of radioactive material even in the event of a high speed collision at sea. Another important consideration is that the study has shown that there are good prospects of achieving future improvements in design by further development of reactor techniques and by changing to gas turbine prime movers. Although these developments are regarded as long term and unnecessary for the present project, they represent an important advantage of the system. Contrary to the view that the high-temperature gas-cooled power reactor will take many years to develop, the research and development work associated with the present proposals suggest that a reasonable time scale is possible. It would involve co-ordination of the design and development programmes, but if a full-scale effort were to begin at the beginning of 1960 it should be possible to launch a prototype ship by the end of 1964, according to the authors of these proposals.

The reactor system proposed is a high-temperature gas-cooled design incorporating similar basic principles to those of the experimental reactor "Dragon" designed by the A.E.R.E. The construction of this latter project is supported by the O.E.E.C. and completion is planned for the end of 1962.

According to the de Havilland proposals two reactors, having a total weight of 2400 tons, would be installed in tandem in the ship, giving a total heat output of 150MW. The reactors could operate independently—a considerable safeguard in the event of failure of one unit. Hatches would be required in the decking above the reactor to allow access for refuelling, but apart from that the structure could be continuous, added strength being imparted to the ship thereby.

The fuel to be used in the reactor is a mixture of uranium-235 and thorium in ceramic form bonded into graphite pellets, contained in sealed impermeable graphite blocks which give additional neutron moderation. Helium gas at a pressure of 1000 lb per square inch is pumped through a large number of coolant holes in the core and transfers the heat produced to six boiler units projecting above the reactor pressure vessel. The use of an all-ceramic core permits safe operation at temperatures in excess of 1000 deg. Cent. (1832 deg. Fah.) and the large temperature difference between the fuel and steam results in a high core heat rating, small boiler size, and low pumping power loss. The steam conditions (600 lb per square inch, 850 deg. Fah.) correspond to those at present used in naval machinery.

The integration of the boiler-circulator units with the pressure vessel (as illustrated in Figs. 10, 11 and 12) results in a compact plant layout and enables a secondary containment vessel to be fitted inside the main biological shield. No additional shielding is necessary, therefore, to protect against leakage into the secondary containment. A laminated iron and water shield is used to reduce weight and act as a tertiary containment vessel. It also affords protection to the pressure vessel in the event of a collision.

Calculations show that in the event of a complete failure of the coolant system the decay heat produced after shut-down will be adequately transferred to the surrounding structure by conduction and radiation without an excessive rise in core temperature. Further study and experimental work is required to prove this point beyond doubt.

It is predicted that refuelling will be necessary at intervals of not less than four years and there is strong evidence to suggest that much longer periods of operation may be realised. This results from the good conversion factor and the characteristics of the U233 produced with this system.

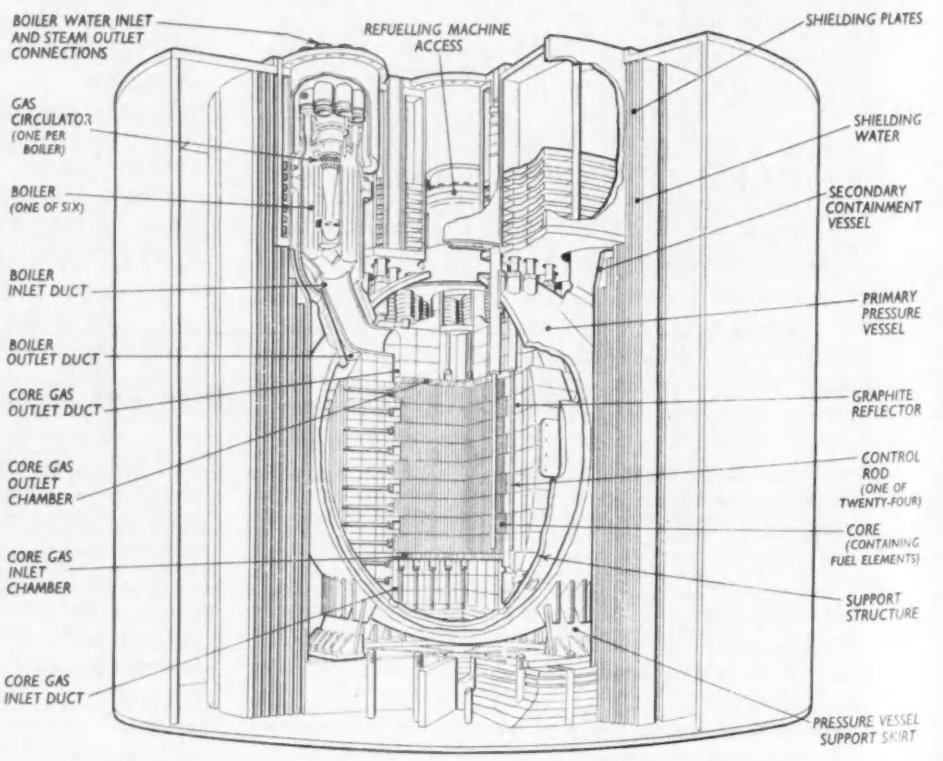


Fig. 11—Cutaway drawing of de Havilland's proposed h.t.g.c. marine reactor

Radiation damage effects to the fuel are minimised by the dilute dispersion of fuel in the graphite matrix.

An estimate of the cost of the first production unit (less core fuel blocks) indicates a figure in the region of £1,400,000 for a twin reactor installation (i.e. £28 per shaft horsepower). Low fuel cost results from a low initial investment (67 kg U235) and the long core life.

A tentative research and development programme suggests that a prototype ship installation could be completed by the end of 1964 and the overall cost of this five-year programme would amount to about £13,000,000. The system is considered to have considerable development potential. The power output of the reactor could be increased by increasing the pumping power, the circuit pressure, and the fuel element temperatures. The acceptance of an active primary circuit would permit the use of an all-beryllia moderated core, would greatly extend the core life, and would make a period of twenty years between refuellings feasible. The use of a simple closed cycle gas turbine in place of the steam plant now proposed would, the firm states, reduce the specific cost of the complete propulsion system by about £20 per shaft horsepower.

Main Particulars of de Havilland H.T.G.C. Marine Reactor

Moderator	Graphite
Coolant	Helium
Heat output per reactor at full power	75MW
Coolant pressure	735 lb per square inch absolute
Coolant temperature at reactor inlet	200 deg. Cent.
Coolant temperature at reactor outlet	700 deg. Cent.
Maximum temperature at centre of fuel pellet	Approx. 1500 deg. Cent.
Maximum temperature of graphite	Approx. 900 deg. Cent.
Pumping power per reactor	530kW
Steam temperature	850 deg. Fah.
Steam pressure	600 lb per square inch absolute
Total estimated weight of installation (two reactors)	2400 tons
Predicted endurance at full power without refuelling	400–650 days
Core height	6ft
Core equivalent diameter	6ft
Reflector	2–2½ft graphite
Number of fuel columns	1729
Number of fuel blocks per column	Nine
Fuel	Uranium carbide and thorium carbide
Initial uranium enrichment	90 per cent.
Total weight of Uranium-235 in core	67 kg
Total weight of Thorium-232 in core	674 kg
Average thermal flux	4·55 by 10^{13} n/sq. cm/sec.
Reactor mean rating	101MW/tonne fuel
Centre channel mean rating	Approx. 101MW/tonne fuel
Average fuel burn-up	65,600MW days/tonne fuel

A compact layout is claimed for the design proposed. The height of the reactor and shielding is less than 25ft and the overall diameter is 25ft 4in, the secondary containment being inside the main biological shield. The specific weight is given as 100 lb per shaft horsepower for the reactors and boilers. Vertical and lateral accelerations of 13 *g* and 6 *g* are allowed for in the design. Inherent characteristics of such a reactor are its large negative temperature coefficient and natural dissipation of shutdown heat.

BABCOCK AND WILCOX PRESSURISED WATER REACTOR SYSTEM

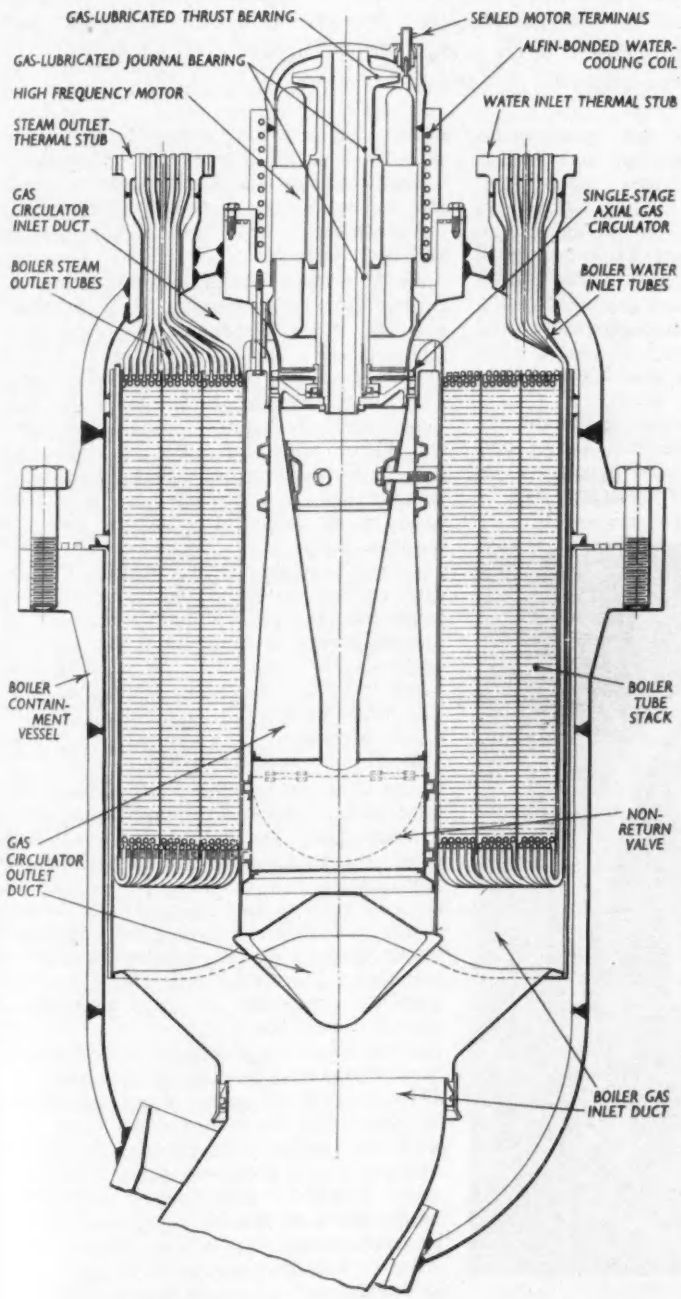
The project submitted by Babcock and Wilcox, Ltd., at the invitation of the Civil Lord's Committee, is for plant incorporating a pressurised-water reactor.

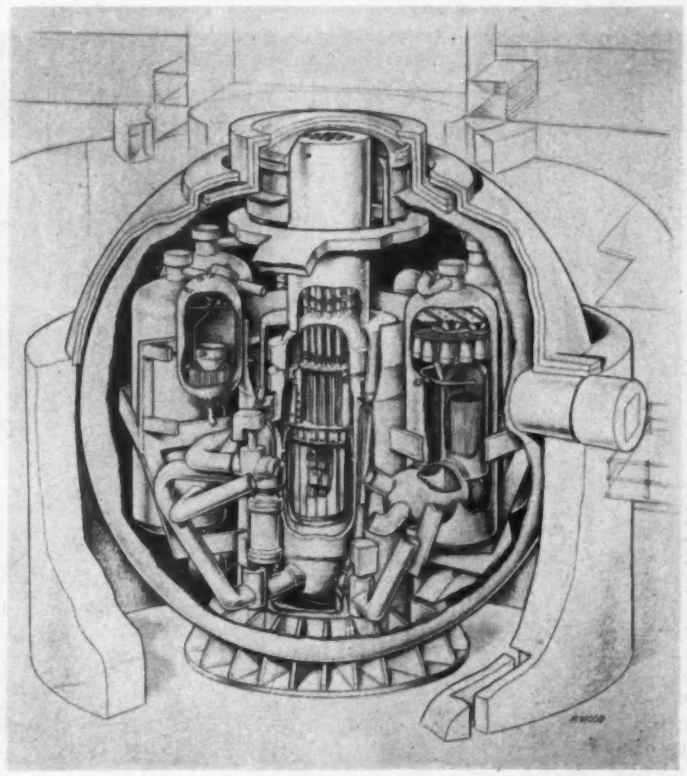
Though it is basically similar to that now in an advanced state of construction by the Babcock and Wilcox Company, of America, for the N.S. "Savannah," (the world's first nuclear propelled merchant vessel) the plant now proposed is designed for a power output two and a half times as great as that for "Savannah," within only 20 per cent more space, an improvement which indicates the intensive development of this design by Babcock and Wilcox, Ltd. (See page 826.)

This company claims to be in a position to undertake now, at a firm price, the design and manufacture, in Great Britain, of a proven and reliable plant with the required output guaranteed, which could be at sea by the end of 1962.

In a pressurised-water reactor plant, ordinary water is used as the reactor coolant and as moderator. Raised to a high pressure and temperature by absorption of heat from the reactor core, this water is circulated through heat exchangers which generate steam to drive conventional turbine propulsion machinery. The fuel is enriched uranium, and the fuel elements are of a type for the manufacture of which the necessary information, techniques and experience for manufacture of the fuel elements are available to Babcock and Wilcox in Great Britain.

The pressurised-water reactor system is inherently stable in operation. In the design submitted great attention has been paid to requirements of safety from all aspects. For example, it is so designed that there will be natural circulation in the event of a pump failure. The large water





Figs. 12 and 13—(Left) Boiler and gas circulator for de Havilland's proposed h.t.g.c. marine reactor. (Right) Cutaway view of the Babcock and Wilcox pressurised-water reactor plant design for marine propulsion

capacity of the boilers allows adequate time for emergency action by providing a "buffer" between the requirements of reactor and turbine. Ample provision has been made against any general boiling of the coolant, which could result in instability and formation of deposits in the reactor circuit. The reactor would be capable of operating continuously at full power with as much as 5 per cent of the fuel elements in a failed condition—a very unlikely event. The turbines and condensers are completely isolated from the reactor coolant circuit, so preventing any mutual contamination. The appropriate water treatment can therefore be applied to each circuit and the resulting purity of the coolant water minimises any induced radioactivity. Hence approach to plant within the containment vessel for maintenance, &c., is possible within minutes of shut down.

The containment vessel is designed to be strong enough to prevent the escape of any radioactive material in the event of mishap to any or all of the pressure parts in the reactor and boiler circuits housed within the vessel. As no special fluids are used, several alternative methods can be employed to replenish the coolant and moderator in the event of an emergency.

Main Particulars of the Babcock Pressurised-Water Reactor for Ship Propulsion

Reactor thermal output	180MW
Average coolant operating temperature	Approx. 500 deg. Fah.
Average coolant operating pressure	1750 lb per square inch
Fuel charge (enriched uranium dioxide)	Approx. 9 tons
Evaporation	616,000 lb per hour
Steam pressure (saturated)	410 lb per square inch
Steam temperature	447 deg. Fah.
Containment vessel dimension	42ft 6in diameter
Weight of plant (including reactor, steam-raising units, ancillary equipment, overall containment and shielding)	Approx. 3000 tons

Enrichment of the fuel charge is in the range from 2 to 4 per cent, a range which is influenced by the use of either stainless steel or Zirconium for the cladding and structure of the reactor core. the fuel charge is sufficient for 500 days seagoing service at full power before refuelling is necessary. This corresponds to two to five years' service depending upon the kind of vessel and the length and nature of the voyages. The weight of the complete plant (about 3000 tons) is equivalent to one week's supply of fuel-oil for the conventional boilers of a propulsion plant developing the same horsepower in the same kind of vessel. The heat output of the reactor is designed to produce a shaft horsepower of 65,000.

Capital costs of the complete plant will depend largely on the requirements of any safety precautions such as resistance to shock, and measures to meet special port regulations, &c., additional to the many safety measures already fully embodied in the design. The company considers that for the kind and size of vessel envisaged overall cost (including fuel and operating costs) will be economically competitive with that for a conventional propulsion plant. Eventually it is expected that all necessary facilities for the manufacture of fuel elements will be available in Great Britain. It is forecast that the cost of fuel will lie between 0·3d. and 0·6d. per shaft horsepower per hour depending on the kind of fuel element employed and the source from which it is obtained.

(*To be continued*)

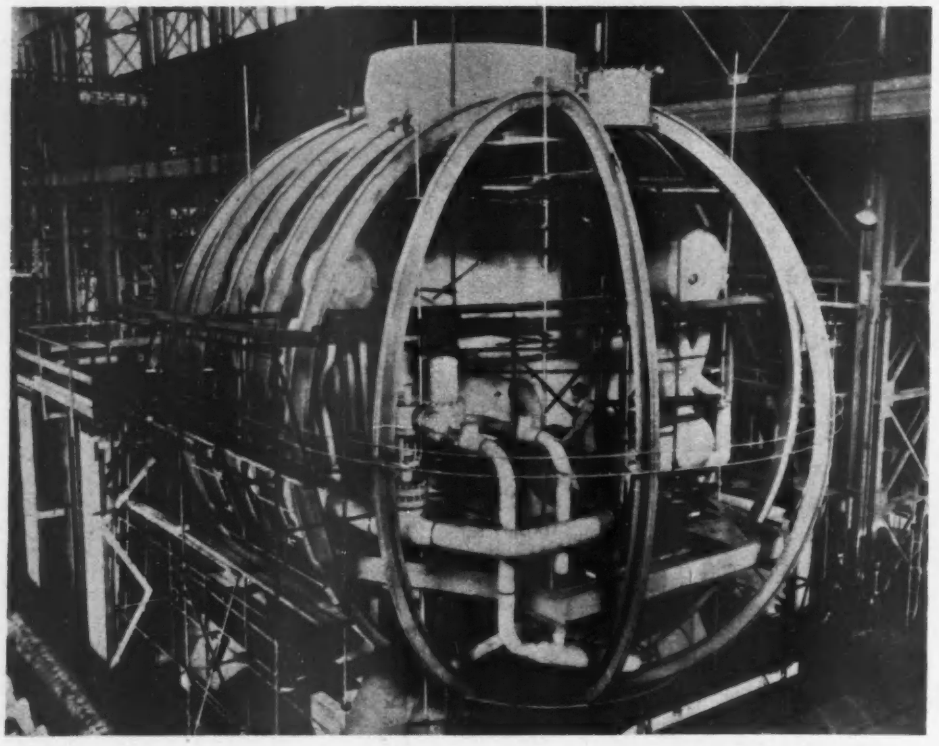


Fig. 14—Full-scale wooden model of the pressurised-water reactor plant designed by the Babcock and Wilcox Company of America for the N.S. "Savannah." This model is being used to finalise details of construction and layout

International Convention on Transistors

The International Convention on Transistors and Associated Semiconductor Devices, promoted by the Electronics and Communications Section of the Institution of Electrical Engineers, was opened at Earls Court, London, yesterday (May 21) by Viscount Hailsham, the Lord President of the Council, who is the Minister responsible for Scientific Research. We give below some details of the programme and a general survey of transistor development. An account of the associated exhibition at Earls Court appears on page 801.

THE programme of the International Convention on Transistors and Associated Semiconductor Devices extends until Wednesday next, May 27. Sessions are being held in the Warwick and Richmond Halls of the Earls Court Exhibition Hall, S.W.5, and the associated scientific exhibition in Hall D. Admission to the exhibition is by ticket obtainable from Industrial and Trade Fairs, Ltd., Drury House, Russell Street, London, W.C.2, who organised the event on behalf of the I.E.E.

There will be twenty-three sessions of the convention (eleven specialist and twelve general) at which some 200 papers will be presented and over thirty lectures will be given. Their scope is indicated by the session titles: "Basic Theory," "Materials," "Characteristics and their Measurement" and "Transistors as a Circuit Element," "Applications," and "Technology (Design and Manufacture)."

At the opening session lectures were given by Professor J. Bardeen, Dr. W. H. Brattain, and Dr. W. B. Shockley, who were joint recipients of the Nobel Prize for their invention of the transistor ten years ago. The lecture by Dr. Brattain, of the Bell Telephone Laboratories, entitled "Historical Development of Concepts Basic to the Understanding of Semiconductors," recalled that the experimental phenomena characteristic of semiconductors, such as negative temperature coefficient of resistance, photo-conductivity, rectification or cats whisker detection, photo e.m.f. and large thermal e.m.f.s of both signs were all known before the beginning of the twentieth century. Faraday noted the negative temperature coefficient of silver sulphide in 1833. The other phenomena were observed in the order mentioned by scientists of whom some are now almost forgotten.

The discovery of the Hall effect in the later part of the nineteenth century added another piece to the puzzle when such measurements were made on semiconductors. Slowly, physicists began to realise that the signs of rectification, photo e.m.f., thermal e.m.f. and Hall effect were all correlated. If the sign of one was known for a given specimen of semiconductor, then the others could be predicted. In these materials, it was as if the current carriers were electron-like but could be either positive or negative. How this could be was the big question. How two different relatively pure samples of the same material could behave in one case as if the carriers were negative and in the other case as if they were positive was even more difficult to understand. The advent of quantum mechanics gave the basis for understanding the positive charge carrier (hole). The resurrection of the elementary semiconductor, silicon, as an essential material for the radar detector of the second world war and the later development of germanium, focused attention on these

relatively simple semiconductors. After the war, basic research directed towards attempts to understand these phenomena led quite rapidly to the discovery of the transistor.

Professor J. Bardeen, of the University of Illinois, spoke on "Basic Research on Semiconductors—A Review." After a brief outline of the accomplishments of the past decade of research on semiconductors, particularly with germanium and silicon, and of current problems, it was shown that although most of the basic concepts date from the 'thirties or earlier, it is only in recent years that accurate quantitative correlations between theory and experiment have been obtained. These have been made possible by experiments on nearly ideal crystals, with impurity elements under precise control, combined with new theoretical developments. With only a few basic material parameters, such as effective masses, determined empirically, the theory is able to account for intricate detail of complex phenomena.

Research has led not only to an increased knowledge of conduction in these materials, but has aided understanding of basic processes in such related fields as photoconductivity, luminescence, plastic flow, surface physics, impurity diffusion, and solid state chemistry, all of which are dependent on small concentrations of impurities or other crystal imperfections. Much of current research is in these latter areas, important for device fabrication and reliability. There is also interest in other semiconductor materials, including those with low carrier mobilities for which current theories are not satisfactory.

Transistor Development and Prospects

Applications of transistors are becoming so numerous that many of those who use them may not be specialists in the semiconductor field, and may perhaps overlook other possibilities of these devices which might be of use to them. To serve as a background to the convention and a source of reference to all participants, a review paper has been prepared by R. G. Hibberd of The British Thomson-Houston Company, Ltd., and has been circulated with the convention papers and lecture abstracts themselves. This contribution, entitled "Transistors and Associated Semiconductor Devices—A Review of Progress" is abstracted in the following paragraphs.

At present, apart from work in universities and Government laboratories all over the world, there are well over eighty commercial companies engaged on the development and production of semiconductor devices—about fifty in the United States, eighteen in the United Kingdom, ten on the Continent of Europe, eight in Japan, and some effort building up in Canada and Australia. Although, as in other spheres, we have little knowledge of activities in the Soviet Union, there can be little doubt that considerable effort is also being expended there.

Until 1953, production was only very small, and mainly of an experimental nature. The subsequent build-up has been progressive. In 1958, about 50,000,000 transistors and 100 million diodes (including rectifiers) were made in the United States, and about 4,000,000 transistors and 6,000,000 diodes in this country. Several estimates have recently appeared of the possible trend of future production of these devices. Typical of these are that, in 1965, the output of transistors in the United States will be about 250 million and of diodes 350 million, while, in this country, the output of each may be about 50,000,000. [A diagram reproduced in the paper indicates that, in both countries, the total output of semiconductor devices will overtake that of receiving valves by about 1962.]

In this country, progress of semiconductor work, although not quite comparable with that in the United States, is in itself quite impressive. The silicon radar crystal was pioneered in this country, and notable work was carried out on the processing of germanium from flue dust. The germanium power rectifier was quickly developed, and a 300kW unit using germanium cells was installed in 1953. With transistors, mention should be made of the development of the post-alloy diffusion technique and the cold-weld method of encapsulation. A recent British development of far-reaching importance is the preparation of very-high-purity silicon by a silane process. At least six or seven new factories with air conditioning and other special features have been erected, and production is building up. So far, the production of transistors has, in general, been limited to the p–n–p alloy type, but other types are gradually appearing to meet the growing demand as more application work proceeds.

Germanium and silicon diodes and rectifiers have been developed to cover a very wide range of operation, from the silicon-mixer crystal diode, handling a few microwatts at 30 Gc/s to the silicon power rectifier handling up to 20kW per cell at mains-supply frequency. The characteristics of silicon junction rectifiers being made at present are so good that it would seem reasonable to forecast that, for all general-circuit d.c. supplies and industrial medium-power supplies, they will be accepted standard rectifiers of the future. Low-power (1A) rectifiers, with junction diameters of 0·025in, can be made with working peak reverse voltages of up to 1·5kV, the reverse current at this voltage being only a few microamperes. In the United Kingdom, the highest-voltage type commercially available at present has a reverse voltage of 600V, with the majority in the 300–400V region. A miniature silicon rectifier is now available in a glass encapsulation similar to the small point-contact diode. It uses a diffused-silicon pellet and has reverse voltages of up to 600V with current ratings up to 400mA.

The common feature of all junction transistors is the narrow base region between the emitter and collector regions. The finite transit time of the electrons or holes across this narrow base region sets an upper frequency limit to the transistor and so the actual thickness of the base region is the first essential design requirement. A further requirement for good high-frequency performance is a low value for the product of collector capacitance and series base resistance. This often introduces a limit at a lower frequency than the base-width limitation. Thus, for good high-frequency operation, the junction area must be reduced, and at present this automatically imposes a power limitation on high-frequency transistors. On the other hand, for high-power working the collector and emitter areas must be increased, and so we have a frequency limitation on power transistors.

Up to the present, the vast majority of transistors produced have been of the germanium-alloy junction type. This particularly applies to Great Britain and Europe. In the United States, grown junction transistors of both germanium and silicon are also readily available. Grown transistors and surface-barrier transistors are now available to some extent in this country, and more recent types such as diffused transistors, drift transistors, post-alloy diffused transistors and silicon transistors are all making headway and if not already available in preproduction form, will be in the near future.

The question of the upper frequency limit of operation is one of temporary limitation, depending on the progress of development. Diffused-structure transistors have been made to operate at 1 Gc/s, and doubtless this figure will be increased—the problem being largely one of technology. It should always be remembered, however, that the base width of a 10 Mc/s transistor compares with the grid-cathode spacing of a 1 Gc/s thermionic valve, and so the difficulties must not be underrated.

As to further comparison with the thermionic valve, the obvious advantages of the transistor, such as the absence of a heater, low-voltage operation, small size, rugged construction, &c., have all been stressed. There are, in addition, other advantages. Because of the low junction temperature, the transistor runs relatively cool in operation, and thus associated components are not heated as with the thermionic valve. But perhaps the most far-reaching feature of the transistor is the fact that either electrons or holes can be used as the current carriers, resulting in the alternative n–p–n or p–n–p types, whereas with the thermionic valve we are limited to a flow of electrons only. This means that a completely new series of transistor circuits can be devised combining the two types, such circuits being impossible with valves.

As indicated earlier, to extend the high-frequency range of a transistor, it is necessary to decrease the base width, and also both the collector and emitter junction areas. For high-frequency grown-germanium transistors, the cross-section of the bar is reduced to 0·015in square and the base width to 0·0005in resulting in a maximum frequency of about 15 Mc/s. Similarly the alloy-transistor high-frequency range is extended by reducing the collector and emitter dots to 0·015in and 0·010in, respectively, and the base width to 0·0005in.

A further development of the high-frequency grown-junction transistor is the so-called tetrode. In this a second base contact is made opposite to the first. A transverse bias, applied between these two base contacts, has the effect of confining the transistor action to a region near one of them. This reduces the effective area of the transistor, thus decreasing both the collector capacitance and the series base resistance, and increasing the maximum operating frequency up to the region 30–40 Mc/s. Silicon tetrodes have recently been developed for operation up to 100 Mc/s.

In the drift transistor a resistivity gradient is built into the base region so that a field is produced which sweeps the carriers across at a higher speed, thus reducing the transit time. Furthermore, a lower impurity concentration is produced in the base region adjacent to the collector junction, and so the collector capacitance is reduced. Thus an increase in maximum operating frequency is obtained, up to about 30 Mc/s. The alloy drift transistor could well emerge as a preferred standard type, since, to some extent, it combines the attractive features of the high-frequency alloy and tetrode transistors.

Surface-barrier transistors use a process known as electrolytic jet etching to produce very thin base widths with reduced junction areas. A typical operating frequency of the transistors so produced is in the region of

50–70 Mc/s. Owing to the extremely small dimensions the power rating is low.

Very small base widths have been obtained by a process of diffusion after alloying the emitter region. This process, known as post-alloy diffusion, was pioneered in this country. Indium containing a suitable donor impurity is alloyed into p-type germanium, and the structure is then subjected to a high-temperature cycle during which the donor diffuses into the p-type wafer to produce a thin n-region. This appears to be a very promising method and seems capable of producing units for operation up to 200 Mc/s.

If a thin layer of intrinsically pure semiconductor is included between the collector and the base layer, the collector-to-base capacitance is reduced, resulting in a higher operating frequency (p.n.i.p. transistor). A higher collector voltage will also be possible. Although these units were successfully demonstrated some time ago, they have only recently become available commercially.

The fact that the diffusion process allows good control of penetrations down to a few millionths of an inch indicates that it is an ideal method for producing the thin base layers necessary for very-high-frequency transistors. Such a transistor, capable of operation up to 500 Mc/s, has been described and more recent information is that units of this type have operated at over 1000 Mc/s.

A more recent possibility, still in the development stage, is the "spacistor." Carriers are injected into the space-charge region of a reverse-biased junction. This makes operation independent of carrier lifetime, and possible operation up to 10 Gc/s has been mentioned.

The field-effect transistor is a unipolar device, in which the flow of electrons down a bar of semi-conductor material is controlled by means of an inversely biased p–n junction on the side of the bar. The depletion layer of the junction extends into the bar, restricting the flow of electrons to an extent depending on the inverse voltage across the junction. A recent version of this device, called the "technetron," is claimed to operate up to 500 Mc/s.

A complete range of germanium power transistors is now available with permissible collector dissipations from 0·5W to 55W (25W in the United Kingdom). These are, in general, p–n–p transistors made by the alloy process, but at least one n–p–n unit for 7W has been announced. With silicon, a double diffused structure is used. Units are now available up to about 80W (37·5W in the United Kingdom).

Any junction transistor can be operated as a reasonably efficient electronic switch in the common-emitter arrangement, a large collector current being switched by means of a small base input current. Now appearing on the market are transistors specially designed for this purpose, for application in computer circuits and the like. The so-called avalanche transistor, which operates into the current-multiplication, or avalanche, region of the collector junction characteristic, has properties very suited to switching, with fast rise times. Although many experimental units have been made and demonstrated successfully, no production units are yet available. Surface-barrier transistors can be used for very fast operation, switching rates in excess of 20 Mc/s being claimed by the manufacturers. At present, extensive development is proceeding on devices with a bistable characteristic of the thyratron type. The main feature of these devices is that they can be triggered into conduction by means of a small short-duration pulse.

The commercial demand for photo-electric devices is small compared with that for rectifiers and transistors, which has adversely affected the priority given to their development. However, a small number of junction photo-diodes and photo-transistors are available. In effect, these consist of conventional junction-diode or transistor structures, mounted in such a manner as to receive incident light on the junction. They require a voltage bias supply, and their output current level is increased by increasing the intensity of incident light. A p–n junction can also be used as a photo-voltaic device, such as the silicon solar battery, which converts solar energy into electrical energy with an efficiency of up to 11 per cent. The new multi-region devices, such as the four-layer p–n–p–n diode will lend themselves to photo-electric operation as devices which can be triggered into conduction with a light pulse.

In 1952, a life of 70,000 hours was forecast for the point-contact transistor, based on the extrapolation of overload operation. Subsequent experience has indicated that this is a very reasonable estimate. With junction transistors, manufacturers are now quoting estimated lives of 100,000 hours. A few typical examples of operating reliability can be quoted. With one particular type of hearing aid, 70,000 units of which are in the field, only one known failure occurred in two years of operation; 5000 transistors in the "Leprechaun" computer have operated for 3000 hours without a single failure.

The transistor art has been continuously changing over the last few years, and no doubt will continue to do so for some time in the future. While the processes of diffusion and alloying appear to be possible permanent features of device fabrication, it would be fairly safe to predict that, in the search for higher-frequency and higher-power operation, new structures and techniques will be devised that may have a pronounced effect on the redesign of existing devices. Furthermore, devices such as the field-effect transistor, Shockley's unipolar analogue transistor, the "spacistor," new multi-region devices, parametric amplifiers, Hall-effect devices and thermo-electric devices will each be the subject of considerable development, and some of them will doubtless come to fruition.

It is confidently expected that the high-frequency limit of the diffused germanium transistor will be increased to several thousand megacycles per second, and there seems to be no fundamental reason why power transistors with collector dissipations approaching a kilowatt should not be possible. Transistors for high-speed switching, up to 100 or 200 Mc/s, will become available, and a range of p–n–p–n devices for computer and power-control applications will become established.

In addition to germanium and silicon, there are a number of possible starting materials, known as compound semiconductors, and much effort is going over to them for special applications. For example, work is proceeding on silicon carbide and indium phosphide which, because of their high energy gap, should be suitable for high-temperature devices—the former up to 500 deg. Cent. Compounds with high mobilities, such as indium antimonide and indium arsenide, are being developed for use in Hall-effect and photo-electric devices. At present, however, there is still much to accomplish, both in the preparation of these compounds and also in their application to devices.

Conference on Investment Casting

THE first annual conference of the British Investment Casters' Technical Association was held in London on May 11 and 12, and nearly a hundred members and guests attended the dinner held in connection with the conference. In proposing the toast of the investment castings industry at the dinner, Mr. L. R. Beesley, director of engine production in the Ministry of Supply, dealt with the growth and progress of the aircraft industry. He said that investment casting had grown to its present importance mainly as a result of the demands of the aircraft industry in its search for new materials and production methods. He suggested that investment founders should investigate the problems presented by new alloys and, in an endeavour to reduce prices to compete with orthodox production methods, turn its attention to combining investment casting with sand casting methods.

The chairman of the association, Mr. D. H. Armitage, spoke of the difficulties which had been faced as a result of a decline in orders, but he was confident of the success of this relatively new industry as a result of the development and research work it was carrying out. Ingenieur H. J. Meerkamp van Embden, the chairman of the European Investment Casters' Congress, was a guest at the dinner. He said that investment casting, although generally spoken of as a revival of an old industry, was nothing of the kind; it was a new industry with new techniques based upon modern research and development work. The task facing the industry was to make full use of the results of research and in this task the association had an important role to play.

Six papers were presented at the conference, the first being by Mr. W. S. Fowkes on "Investment Castings and Some Aspects of their Costs." He listed some of the ways the industry would have to adopt to face competition from alternatives or more conventional methods of casting. He said that, generally speaking, the industry was almost wholly engaged in sub-contracting and its survival depended upon its ability to sell its products in the face of such competition. He then went on to give suggestions as to the treatment of the elements of costs, and the broad lines of what he considered a sound policy for the establishment of an accepted and respected industry engaged in the production of investment castings.

Mr. D. R. Wood in a paper on "Some Investment-Cast Alloys for High Temperature Service," reviewed some of the cast alloys amongst the new materials developed to incorporate strength over long periods at elevated temperatures. After listing some of these alloys he dealt with their mechanical and physical properties and foundry techniques for their production. In his paper on "Mechanical Properties of Some Investment Cast Cobalt Base Alloys," Mr. M. Riddihough dealt mainly with X-40 which, he said, was the only cobalt base alloy now used to a large extent.

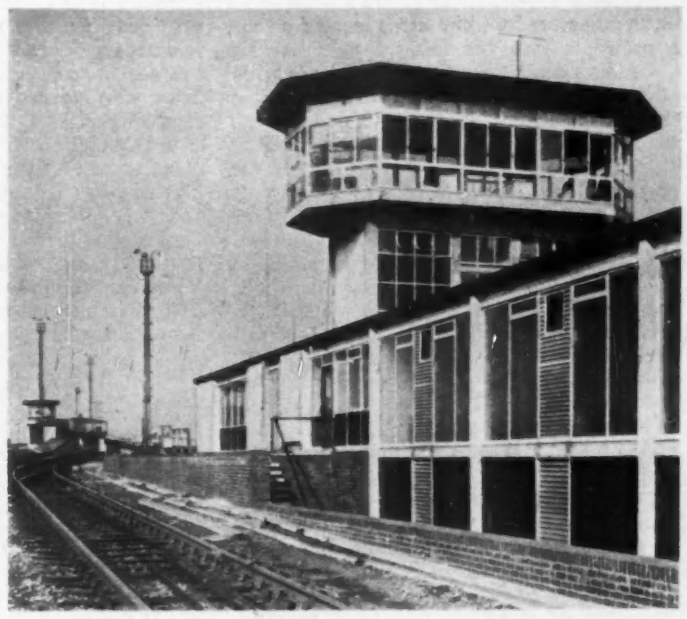
In introducing a paper "Silica Binders for Investment Casting," Mr. J. I. Evans pointed out that an appreciation of the chemical background of binders was often helpful to the user. He dealt in particular with ethyl silicate and silica sol binders and related theory to practical applications, making suggestions whereby close control was possible of the various processes on their use. In connection with these binders there was an unnecessary waste of expensive materials and lack of operational control in many cases owing to the fact that rule-of-thumb methods prevailed over carefully planned formulations. A better understanding of the range of possible formulations might suggest opportunity for the use of ethyl silicate or silica sols where previously they had been thought unsuitable on functional or economic grounds.

On the subject of "Process Control in the Investment Shop" Mr. J. Mitten pointed out that investment casting involved a very large number of variables, the control of which became quite difficult. He dealt in some detail with technical control of conditions and procedures as applied in the investment shop from the receipt of the wax cluster to the completion of the finished mould prior to casting.

Temple Mills New Hump Marshalling Yard

No. II—(*Concluded from page 760, May 15*)

One of the most important localities in the Eastern Region for marshalling of freight traffic has now been completely modernised and ranks as the most up-to-date yard in Great Britain. In a previous article the general location and principles of working were described; in the present one are details of the automatic point setting, and the signalling in the approaches to the yard.



FOLLOWING the general references to the method of point operation in the humping area in the previous article, the working may now be considered in more detail. As the first cut of a train being humped approaches the hump cabin, and the shunter observes the sorting siding into which it is required to be routed, he depresses the appropriate route setting push button for the first route. This selects the required relays in the first bank of storage at the King points group. As the second and third banks on this storage group would be vacant at the commencement of humping, the information fed into bank 1 would automatically step into bank 2 and from there into bank 3. On arrival in the third bank, the King points would be set as required. The information provided by the depression of the button for the second route would pass through bank 1 to bank 2, and likewise, the depression of the third route button would fill bank 1. Assuming these depressions have been made as the "cut" numbers have come into view, the third depression would have been made at about the same time as the first cut was arriving at the King points rail circuit.

The occupation of the King points rail circuit would hold the points and pass the route setting information on to the storage group of the Queen points, where again it would pass from bank 1 to bank 2, whereupon the Queen points would be set as required. At the same time the second setting would step to bank 3 at King points, and the third to bank 2. As the first cut clears the King rail circuit, the King points would be set for the second route. This process would continue as each cut occupies and clears the relevant first rail circuit, so that the points would be set successively ahead of each cut.

In addition to pressing the appropriate buttons for route setting, the hump shunter uses a further set of buttons for indicating to the control tower the number of wagons in each cut. Cuts of more than six wagons are rare, but in those instances in which a cut has more than six wagons the operator uses "cut" button No. 6 for the route setting control, and the remainder of the wagons are added by operating the appropriate buttons on a separate panel for wagon counting indications. Separate wagon counting indications are given by the hump room operator to the control tower, thus indicating the number of wagons sorted into each siding. When the siding is full a black cap is placed over the plunger in the panel in the hump room and no more wagons are sent to that siding even though wagons may have already been marked for it.

A teleprinter transmitter is incorporated within the desk structure and the cuts are initiated from direct connections to the route setting and cut push buttons, no separate teleprinter keyboard being necessary. The depression of one of the route setting buttons and a cut description button on the hump cabin control desk initiates the appropriate code, which is transmitted to the control tower receiving unit. A record of the transmission of the code is printed on a paper tape with the route number of the cut on the left and the number of wagons on the right, and to the right of these figures is a space on which the operator can make pencil notes. A route button on the hump panel when depressed is held down automatically and is not released until the description has arrived in the second storage bank, and the required teleprinter code has been transmitted; when the release has been effected a green "Next route clear" indication is illuminated. An audible warning is given when conditions are such that another route button can be depressed.

In all, there are fifty-nine sets of points leading to the sorting sidings that are electro-pneumatically operated, and of these forty-nine are automatic. Speed in operation is essential, and the points are driven by a cylinder directly coupled to the first stretcher bar. As no passenger traffic is concerned there is no need for facing point locks, and the mechanism can be simplified and speeded-up in operation accordingly. The operating pressure is 25–35 lb per square inch, and the time of operation of a pair of points, from the time its associated rail circuit is cleared to the time the indication of the change of position appears on the control desk, approximates 0·5 second.

A push button is provided on the panel, which, when operated, prevents further operation of the route setting system and releases a maintainer's panel in the relay room. This maintainer's panel enables the lineman to operate the storage system by hand, by means of switches provided to simulate cuts. Thumb switches also enable individual point movements to be simulated by him and push buttons on his panel rail circuit repeating relays to be energised, simulating the passage of a cut. By this means the lineman is able to operate the storage system in the relay room and quickly test the circuits when necessary.

Control Tower

The control tower (heading illustration and Fig. 8) is mainly concerned with the operation of the retarders but can set routes manually in the event of failure of the automatic equipment. In the control tower there are two desks (Fig. 9) of similar design to that already described for the hump cabin. The desk for the North half of the yard carries a panel with a track diagram on which are shown routes 25–48, the transfer sidings and associated lines over which the North operator has control. Also shown on this panel is the humping signal and a position-light ground signal worked by Temple Mills West and controlled from the tower for movements back from the transfer sidings towards the hump, or across into No. 2 reception road. The two-position thumb switches and indications for these signals are located adjacent to their signals on the panel. Red and green indications are provided for the hump signal, whilst for the shunt signal a "locked" and "free" stencil indication is shown. The points from the transfer siding to No. 2 reception road are worked by Temple Mills West and released by the control tower, a two-position thumb switch being provided on the panel for this purpose. Stencil indicators, indicating "locked" and "free," are associated with this thumb switch.

The desk for the South half of the yard controls the King points, routes 1–24 and the brake van siding; it also includes a thumb switch for control of the hump signal, as on the North desk. In addition, it includes two-position thumb switches for operation of trailing points from the yard sidings. On both desks the control of the points in the sorting sidings is effected from three-position thumb switches geographically located. Normally, with automatic point working these switches lie in their central positions; but a push button is provided alongside each for cancelling a route during automatic working if it appears to the tower operators that a cut is likely to catch up with a preceding one. The storage of the second cut could thus be cancelled. Should it be desired to re-route a cut during its progress down the yard, this could be done merely by operating the individual point thumb switches as required and immediately replacing them to their centre positions when the relevant point rail circuits "clear." This would then leave all other route switches unaffected. The lie of all points is indicated

on the diagram by white lights located on the appropriate leg of the points.

On both desks " cut " indications are given adjacent to each leg of a group of sidings from the approach to the King points down to the approach to the individual groups A or B or C, and so on. These indications show the progression of the cuts of wagons down to the particular group of sidings to which they are going; for example, the indication " A64 " represents a cut of four wagons proceeding to No. 6 siding in group A. These indications are received from the wagon counter panel previously described and include the indications N and L for non-retarders and long wheelbase vehicles. Also in these panels are given indications G, B, H, L, which are received from the electronic equipment described in connection with the primary retarders, according to whether the wagon is a good or a bad runner and if heavy or light. This enables the operator to judge the amount of retardation which should be applied by means of the secondary retarders.

Services in the New Yard

The compressor plant supplies air for point operation, and for working the retarders (Figs. 10 and 11). The controls of this plant are arranged so as to permit the compressors to be interchanged or isolated at will. The main air receiver is located at the control tower with two additional receivers of the same size, one located adjacent to the primary retarder and the other at the secondary retarders. Each submain air receiver serves local air receivers which are located adjacent to each retarder. To avoid obstruction in the yard, all air receivers are placed in pits below ground level and pipes are laid direct in the ground or in concrete troughing laid at surface level. Compressed air for point operation is obtained through reducing valves from the main air receiver.

The lighting in the new marshalling yard employs colour-corrected mercury vapour lamps mounted at 55ft above ground level on tubular towers. There are seventy-two high-mounting towers installed throughout the yard, sixty-five of which are equipped with three lanterns and seven with two lanterns. Each lantern takes a 400W MBF/U lamp. Access ladders with body guards are a feature of each tower and a working platform at high level is provided to facilitate lamp replacement and maintenance of the lighting units. The average spacing of the lighting towers is 240ft, with reduced spacing at the hump and retarder positions. During hours of darkness it is essential for the operator in the hump cabin to be able easily to read chalked numbers or other identification marks on wagon ends, to enable him to set up the correct route for directing the vehicles to the various classification sidings, and special lighting at the hump summit has been provided. All lighting in the hump retarder and classification sidings is remote-controlled from the hump cabin.

Signalling on the Approach Lines

For controlling traffic on the approaches from the south, or Stratford, end a new route-relay interlocking has been installed, replacing signalling previously controlled by mechanical signalboxes at Loughton Branch Junction, Chobham Farm, and Stratford Loop Junction. The contractor for this work was the Siemens and General Electric Railway Signal Company, Ltd. The control panel in the new box is fitted with panel keys for operating points and signals on the " entrance—exit " principle. The panel itself (Fig. 12) consists of a desk surmounted by a vertical operating panel, on the front plate of which is a reproduction of the layout of the lines and connections located within the control area of the signalbox. Track circuits, points and signals are indicated on the panel by means of illuminated indicators. A rotary key is provided for each signal or each group of signals fixed on the same post. These rotary keys are referred to as " entrance " keys and are located on the panel layout at points corresponding to the geographical position of their associated signals on the site. At the remote end of each signal route on the panel layout is located an " exit " push-button key.

On the panel the track circuits are indicated by means of units illuminated by two telephone-style lamps. They are mounted behind the front plate of the panel in which there are slots to receive the indicating portion, consisting of a lozenge-shaped piece of translucent glass. When a track circuit is occupied by a vehicle a white indication light is displayed. The extent of track circuits is denoted by colours painted on the panel layout. The illuminated indication is situated as close to the centre of the track circuit as practicable, and bears the number of the track circuit. Lines not track-circuited are depicted by two parallel border lines which outline the light green background in yellow.

The profiles of the signals themselves are not shown on the panel but, as previously explained, the positions of signals are denoted by the location of the entrance keys provided for each signal. On each entrance key is engraved an arrow which points out the direction to which the associated signal applies. In addition, two coloured indications are provided close to the entrance key: " red " to indicate the danger aspect of the signal, and " green " for the off aspect.

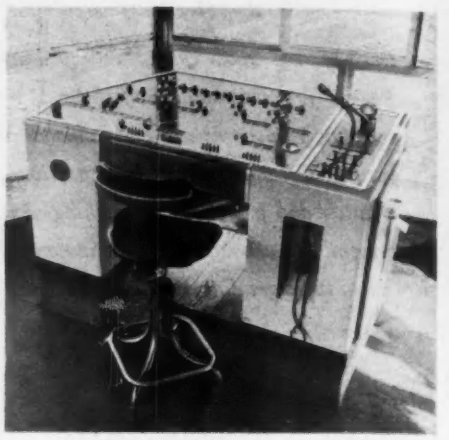


Fig. 9—One of the two control panels in the control tower

Fig. 8—View looking over control tower and north sidings during construction

Points

Each set of points is provided with an individual point-key, and these are situated in a horizontal row along the top of the panel. These keys are provided for test purposes, or for emergency; they are not required in normal working since the points operation is provided for in the route working. The normal and reverse positions of the points are indicated by illuminated stencil indicators situated on each side and level with the top of the individual key. Slightly above the key is a third indication which is normally out but displays a white light when the points are locked, and a red flashing light if they are out of correspondence with the associated operating mechanism. A further set of indications is provided for each pair of points. These are embodied in the diagrammatic reproduction of the points on the panel layout and, when illuminated, display a short strip of white light to indicate the direction in which the points are set. In the following description these indications will be referred to as " point set " indications and the ones against the individual point keys as " point indications."

Method of Operation

To clear a signal for a given route it is first necessary to turn the entrance key, and then to depress the exit key at the remote end of the route. If the point-holding track circuits are unoccupied, the control relays for the various points in the route will operate and the electric point machines on the ground will respond. When the points have thrown, detection circuits prove that the points are bolted and that the switch tongues are fitting correctly to the stock rails. When this has been established, the information is presented to the signalman by the illumination of the " point set " indication. The button of the exit key is also illuminated as a further indication that the operation has been completed. The signal then

Fig. 10—Primary retarder and hump cabin

Fig. 11—View from control tower showing four secondary retarders

clears provided that all controlling track circuits have been proved unoccupied and the point operating mechanisms are locked. The illumination of the associated lock lights at the top of the panel indicates that the latter condition obtains, but this is also proved before the signal is allowed to clear.

The red signal indication on the panel changes to green when the signal has cleared, proving that it has operated and that the signal lamp is alight. On the train passing the signal the latter is automatically placed to "danger" and when the route has been cleared and the entrance key restored the "point set" indications are extinguished. Conflicting routes are electrically interlocked. The "point set" indications provide a useful guide to the signalman should he forget to restore a route before attempting to clear a conflicting one. Points are non-restored, that is they remain in the position to which they have been operated, when the route-operating key and mechanism are restored, until required in the opposite position by another route setting operation.

In cases of emergency it is sometimes necessary to divert traffic by movements over unorthodox routes which are not signalled, and in such cases the necessary point operations are made by means of the individual point keys. Assuming that it is required to operate a pair of points to the reverse position, the individual point key is turned from the centre to the reverse position. When the points commence to move the normal point indication (displaying an illuminated letter N) is extinguished, the lock light displays a red flashing light showing that the points are out of correspondence and, on completion of the movement, the reverse indication (letter R) is illuminated. The lock light then changes from red to white signifying that the points are locked in the position denoted by the point indication. The lock light and point indications follow a similar sequence when they are operated by route setting means. This route relay interlocking comprises:—

No. of routes	123
No. of track circuits	70
No. of signal locations (new)	27
No. of ground disc locations	32
No. of points	42 sets

Temple Mills West Signalbox: Control Panel

Although the panel at Temple Mills West is of different manufacture to the panel at the East box, the contractor being Metropolitan-Vickers–G.R.S., Ltd., the method of operation is similar, the main difference being in the type of "point set" indications provided. These are electromagnetic, the indicating portion being a movable triangular pointer let in to the panel face and located where the associated points are shown diagrammatically on the layout. The running lines and connections between them consist of channels milled into the panel face, the movement of the pointer breaking the continuity of the channel in one direction and restoring it in the other, at the point of divergence, thus indicating the position of the points on the site. Another point of difference is that the exit push buttons are not illuminated when the route is set, a separate indication, located close to the exit key, being provided for this purpose. This route-relay interlocking comprises:—

No. of routes	117
No. of track circuits	50
No. of colour-light signal locations	19
No. of ground disc locations	25
No. of points	38 sets

Communications

The telecommunications network in Temple Mills is self-contained, comprising a 100 line P.A.B.X. in the yard master's office block, the equipment for which is installed in a room on the first floor and the associated single-position switchboard on the ground floor. All signalboxes and offices from Temple Mills East signalbox to Copper Mill Junction signalbox inclusive are provided with an automatic telephone, the majority having an "8" level access to Stratford exchange and selected extensions having "9" level access to the Post Office system. All automatic telephones have "0" level access to the manual operator. Tie lines are provided to Stratford station automatic exchange and a direct junction to the Stratford Control Office.

In addition to the automatic network, the following are all provided with lamp calling keyboards:—Temple Mills East panel and booker boy; Temple Mills West panel and booker boy; Manor Yard signalbox; Copper Mill signalbox; Hump cabin shunter; Hump cabin inspector and the control tower operators.

Only keys and lamps are fitted in the keyboards, all other apparatus being rack-mounted and installed in the relay rooms. A standard keyboard circuit has been developed, which by cross-jumpering on the apparatus rack, can be used to terminate any type of circuit, either automatic, central battery, selective, or omnibus code ringing. Loud-speaking telephones are also provided between signalboxes and shunters' cabins.

A two-way radio network is provided. The fixed station apparatus is rack-mounted and installed in the control tower relay room, the aerial being mounted on the roof. Normally, the radio is operated from the shunter's panel in the hump cabin, an engaged indication being given on the control tower operators' desks. In emergency, either of the control tower operators can take over the radio link, as they have priority over the hump cabin. Four diesel-electric shunting locomotives are fitted with mobile sets, operating from the 90V locomotive battery via a rotary transformer which supplies 230V a.c.

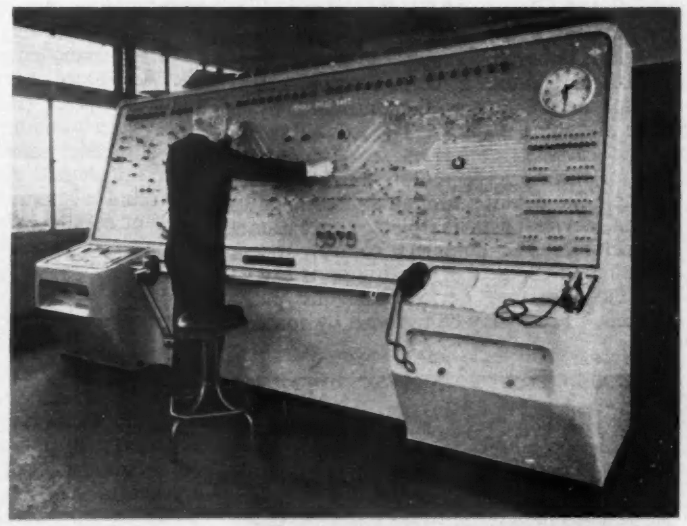


Fig. 12—Route relay interlocking control panel at Temple Mills East signalbox

The cabling, which extends from Temple Mills Lane bridge to Copper Mill signalbox, allows for trunk, telegraph and miscellaneous cables which are installed in concrete surface troughing. The cabling scheme involves over sixty cables and seven main locations. Main distribution frames are fitted at the telephone exchange, Temple Mills East and West signalboxes, and Copper Mill signalbox. A signal

post telephone network is provided and a lineman's circuit taken into every location. The calling facilities on this circuit are either a.c. ringing, or a Klaxon horn fitted on the appropriate signalbox. A loudspeaker system is provided whereby the control tower operators can speak to the wagon chasers or departure area by throwing the appropriate keys on the control panels. The 50W amplifier and spare are rack-mounted and installed in the control tower relay room. An impulse clock system is provided, with a master clock installed in the telephone exchange feeding seventy slave clocks arranged on eight sub-circuits.

The construction of the new yard was carried out under the direction of Mr. A. K. Terris, B.Sc., M.I.C.E., Chief Civil Engineer, Eastern Region. Mr. K. J. Cook, O.B.E., M.I.Mech.E., M.I.Loco.E., Chief Mechanical and Electrical Engineer, Eastern Region, was responsible for the supply and installation of the mechanical and electrical equipment, and Mr. R. A. Green, M.B.E., E.R.D., A.M.I.E.E., M.I.R.S.E., Signal Engineer, Eastern Region, for the resignalling and telecommunications. The earthworks and track laying were carried out under the direct supervision of the District Engineer, Stratford, whose labour forces were augmented by those of Tersons, Ltd.

Main Contractors

The contractors responsible for the main items of plant are as follows: retarder equipment and signalling equipment associated with the hump cabin and control tower and wagon counting equipment, also the wagon description system, The Westinghouse Brake and Signal Company, Ltd.; signalling equipment associated with Temple Mills West and Copper Mill signalboxes, Metropolitan-Vickers-G.R.S., Ltd.; signalling equipment associated with Temple Mills East and Manor Yard signalboxes, The Siemens and General Electric Railway Signal Company, Ltd.; P.A.B.X. telephone equipment, The Reliance Telephone Company, Ltd.; v.h.f. radio telephone equipment, Marconi's Wireless Telegraph Company, Ltd.; 50ft lighting towers, "Usk" tubular steel footbridge, Tubewrights, Ltd.; yard lighting equipment, The General Electric Company, Ltd.; transformers, Metropolitan-Vickers Electrical Company, Ltd.; high-voltage switchgear, British Thomson-Houston Company, Ltd.; high-voltage cables, Johnson and Phillips, Ltd.; medium voltage cable distribution, Siemens Edison Swan, Ltd.; yard lighting installations, Clough Smith and Co., Ltd., Johnson and Phillips, Ltd.; control tower, hump cabin and signalboxes, Kirk and Kirk, Ltd.; staff accommodation buildings, J. and J. Dean, Ltd.; Ruckholt Road overbridge, hump-bridge, culverts, gas and water services W. and C. French, Ltd.; piling, Holmpress Piles, Ltd.; Lea Bridge Road overbridge, Wellerman Brothers, The Butterley Company, Ltd.

International Transistor Exhibition

No. I

The International Transistor Exhibition, promoted by the Electronics and Communications Section of the Institution of Electrical Engineers, in connection with the International Convention on Transistors and Associated Semiconductor Devices, opened at Earls Court yesterday, and will continue until next Wednesday, May 27. This is the first international exhibition to be devoted entirely to transistors and semiconductor devices and while illustrating the advances made in the ten years since the transistor was invented, also indicates the probable pattern of future advance. A first selection of exhibits is reviewed below.

The British Thomson-Houston Company, Ltd.

THE commercial semiconductor activities of the British Thomson-Houston Company, Ltd., Rugby, are represented by exhibits on Stand No. 59, and its research effort on Stand No. 100, where there is a combined display of the work of the A.E.I. Research Laboratory, B.T.H. Group Research Laboratory, M.V. Group Research Laboratory and Siemens Edison Swan Research Laboratory. Among the commercial B.T.H. exhibits, a recent development in control engineering is demonstrated by a static switching display. The exhibit shows an application of contactless sequencing control for three electric motors and illustrates multiple interlocking, timing and contactless output devices which replace conventional contactors. The complete control system contains no contacts or moving parts except for the initiating devices such as push-buttons. These may be replaced by contactless devices if so desired. The static control system is built up with plug-in "logic units" containing a transistor network encapsulated in epoxy resin. Four basic types of unit (Fig. 1) are shown, each type being distinguished by a contrasting colour of resin. Compared with conventional relay systems, static switching is stated to offer increased reliability, freedom from wear, compact installations, exceptionally high operating frequencies, and very low response times.

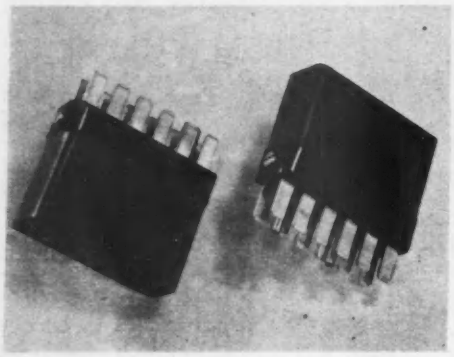


Fig. 1—Plug-in units of a static switching system applicable to motor control. Each contains a transistor network encapsulated in epoxy resin

In the semiconductor power rectifier field, the Associated Electrical Industries Heavy Plant Division (managed by B.T.H.) is showing cell-and-fin assemblies and typical power rectifier stacks. The exhibits include both silicon and germanium cells tested to withstand a momentary inverse voltage of 600V at maximum temperature and suitable for an a.c. crest working voltage of 300V.

Research Laboratories of Associated Electrical Industries, Ltd.

In this group exhibit, the constituents of which are referred to above, the A.E.I. Research Laboratory is showing a working silicon crystal pulling furnace using electron bombardment heating (Fig. 2). Silicon crystals of very low oxygen content can be grown by this new technique. Solid silicon acts as the container for the melt and the usual silica crucible is thus eliminated.

Extensive research on diffusion processes used to make silicon transistors is represented. Diffusion and precipitation in aluminium-doped silicon may be seen, together with the formation of cylindrical p-n junctions round dislocations in silicon.

In another exhibit are shown dislocation arrays revealed in pulled silicon crystals by etching techniques. Extensive research has also been carried out on the examination of silicon surfaces by electron diffraction, both after chemical etching and after high-temperature heat treatments; a three-part exhibit shows contamination of germanium and silicon, physical and chemical change on silicon surfaces during heat treatment at diffusion temperatures, and growth of germanium films.

The B.T.H. Group Research Laboratory shows electro-luminescent panels as practical light sources for information display; control of an electro-luminescent display panel by a retina of high-speed, high-sensitivity cadmium sulphide elements is demonstrated. Recent research to cut the response time of cadmium sulphide photocells by five to ten times without loss of photosensitivity is also represented. Semiconducting glasses containing high percentages of vanadium pentoxide are shown by the same organisation; current is carried through the glass by electrons jumping between vanadium ions of different valency. No polarisation effects are observed when d.c. is applied. The technique of controlled silicon rectifiers is demonstrated by a device initially designed to have a current rating of 5–10A with peak inverse voltages up to 300V and triggering currents in the 10–100mA range. An experimental unit is seen operating in a circuit for d.c. motor speed control, using a phase-shift network in the triggering circuit.

The M.V. Research Laboratory exhibit is an analogue multiplier using a Hall effect unit and associated transistor circuits. The Hall effect multiplier, in the form of a small plug-in unit, comprises a semiconducting plate mounted in the gap of a ferrite pot core assembly, a magnetic field in the gap being derived from a current in a winding of this core. Signals in the form of currents supplied to this winding and to the semiconductor plate give rise to an output Hall voltage proportional to the product of these currents. This product formation can be made accurate to 0·1 per cent. Variation in ambient temperature affects the output at a rate of 0·02 per cent.

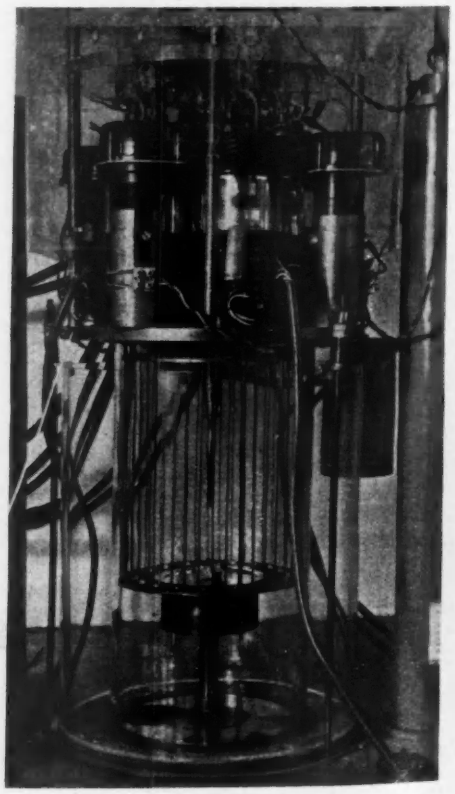


Fig. 2—Silicon crystal pulling furnace using electron bombardment heating—A.E.I. Research Laboratory

Siemens Edison Swan Research Laboratory shows an experimental small-scale crystal growing apparatus enabling very thin base layers to be produced for transistors to operate at high frequencies. As little as 25 grammes is used in the melt. A p-n-p crystal produced in this furnace by the wafer dip method is shown, a wafer of p-type germanium having been used as a seed and a melt prepared containing antimony, gallium and indium. Whilst the crystal was being grown, the antimony diffused into the original slice and formed a thin n-type layer. Other research activities represented are an improved modulator making use of special properties of the XS101 symmetrical transistor ; digital circuits operating at 1 Mc/s with an experimental alloy junction transistor having an alpha cut-off frequency exceeding 10 Mc/s, and an experimental aluminium-bonded diode, and the production of a germanium p-n-p-n switch.

The General Electric Company, Ltd.

Transistor-inverters first developed by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, for aircraft and railway carriage lighting, are now finding wider applications, the latest being to operate a 9in, 6W fluorescent tube in motor vehicles from a 12V d.c. supply. Some of the lighting on the stand is fed by units of this kind. An experimental inverter operating ten 15W fluorescent tubes from 110V d.c. is also shown.

A variety of exhibits show transistorised equipment for telecommunications and associated work. An interference measuring set developed for the G.P.O. incorporates eight germanium junction transistors, three germanium point contact diodes and one silicon junction diode, operated from a 6V internal battery. The set covers the frequencies 150 to 275 kc/s and 550 to 1610 kc/s, measuring interference voltage, electrostatic field strength and electromagnetic field strength. Multi-channel equipment for open-wire and co-axial cable systems includes a channel panel for translating incoming voice frequencies to the required position in the group frequency band 60–108 kc/s. In the reverse direction it provides demodulation to speech and facilities are given for out-of-band signalling if required. An out-of-band signalling unit has been developed to accept d.c. pulses of either −24V, −50V or E from the telephone exchange, and to convert them to pulses of 3825 c/s, which it injects into the standard channel panel. The receiver accepts 3825 c/s from the channel panel, amplifies and rectifies them, and operates a transistor switch circuit which in turn operates a telegraph relay. The contacts are so arranged that the desired d.c. pulses may be transmitted to the exchange.

Subscriber and junction units incorporating pulse modulators and demodulators as required in an experimental electronic telephone exchange are shown. The former consists of a two-wire/four-wire termination at which speech signals (two-wire) are converted to and from amplitude-modulated pulses (four-wire). Speech signals are applied via a hybrid to a simple semiconductor diode modulator to which are applied ½-microsecond pulses. The second unit is similar except that there is no hybrid and the working is four-wire/four-wire.

Research exhibits include an experimental missile guidance equipment (Fig. 3) produced in line with possible future defence requirements. By extensive use of printed circuitry and transistors, marked reductions in weight and size have been achieved, and total operating power has been reduced by more than 60 per cent.

The Pirani gauge equipment in this section of the exhibits was developed for the measurement of atmospheric pressure at high altitudes and was used in the "Skylark" rocket during the International Geophysical Year programme. It measures only 5in by 4in by 4in and uses fourteen transistors. A tuned transistor amplifier is used to drive a bridge circuit containing a Pirani filament, the output of the bridge being fed back to the amplifier input. The combination behaves as an amplitude-stabilised oscillator, the amplitude depending on the rate of heat loss from the filament, and hence on the pressure to which the filament is exposed.

Mullard, Ltd.

The two stands of Mullard, Ltd., Mullard House, Torrington Place, London, W.C.1, are concerned respectively with new devices, developments and applications, and with semiconductor research at the Mullard Research Laboratories.

Among the new devices are the first n-p-n transistors to be introduced by the company (OC139 and OC140). Both are germanium alloy junction transistors designed for high-speed computing circuits and other r.f. applications. Characteristics include current ratings of 250mA peak and 200mA average ; low bottoming voltage of 220mV maximum at a collector current of 50mA ; and low leakage current of 3 microamp maximum (measured at 25 deg. Cent.). Maximum collector voltage is +20V d.c. or peak, and maximum junction temperature is 75 deg. Cent. for continuous operation, or 90 deg. Cent. for intermittent operation.

The OC139 has a minimum cut-off frequency of 3·5 Mc/s and a minimum large-signal current gain of 20 at 15mA collector current. For the OC140 these parameters are 4·5 Mc/s and 50 respectively. The fall-off in gain at high currents is relatively small, the figures being respectively 14 and 35 for the OC139 and OC140 at a collector current of 200mA.

Both types have nearly symmetrical emitter and collector junctions and are controlled for reverse current gain.

New high-voltage industrial power transistors are also shown (OC28 and OC29). These are industrial 6A power transistors (Fig. 4) to withstand a peak collector voltage of 60V while passing a current of 0·5A. They are intended for high-voltage, high-current switching and control applications, the OC28 being suitable, in addition, for d.c. converters operating from fully-charged 24V supplies. At the peak collector current of 6A (for both types) the OC28 gives a minimum large signal current gain of 27, and the OC29 of 45. Both are designed for continuous operation at junction temperatures of up to 90 deg. Cent. (up to 100 deg. Cent. for intermittent use), and are made in the standard American power transistor construction (Fig. 4) which has been adopted for future Mullard power transistors. Half-voltage versions, OC35 and OC36, designed for fully charged 12V supplies, are also shown.

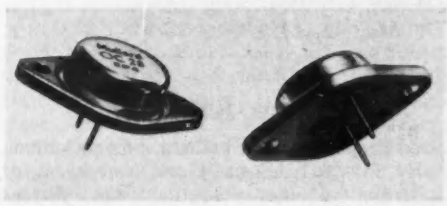


Fig. 4—Industrial power transistors for high-current, high-voltage switching and control applications—Mullard

Specimens are exhibited of a new series of germanium r.f. transistors using alloy diffusion techniques. The first of these, OC170, has an average cut-off frequency of 70 Mc/s and provides a current gain of 80. It is to be followed by further devices, one suitable for use as a mixer at frequencies up to 100 Mc/s with low noise, and others, to come later, having average cut-off frequencies reaching 200 Mc/s and above.

The Mullard Research Laboratories include in their display two electrical networks which simulate transistor behaviour. They are built up on the basis of a theoretical picture of transistor action, and measurement of their characteristics is in effect a measurement of the theoretical model. Comparison between actual transistor behaviour and analogue behaviour enables the theoretical model to be checked ; and elements of the analogue can be adjusted to observe the effects of varying the corresponding quantity within the actual transistor.

(*To be continued*)

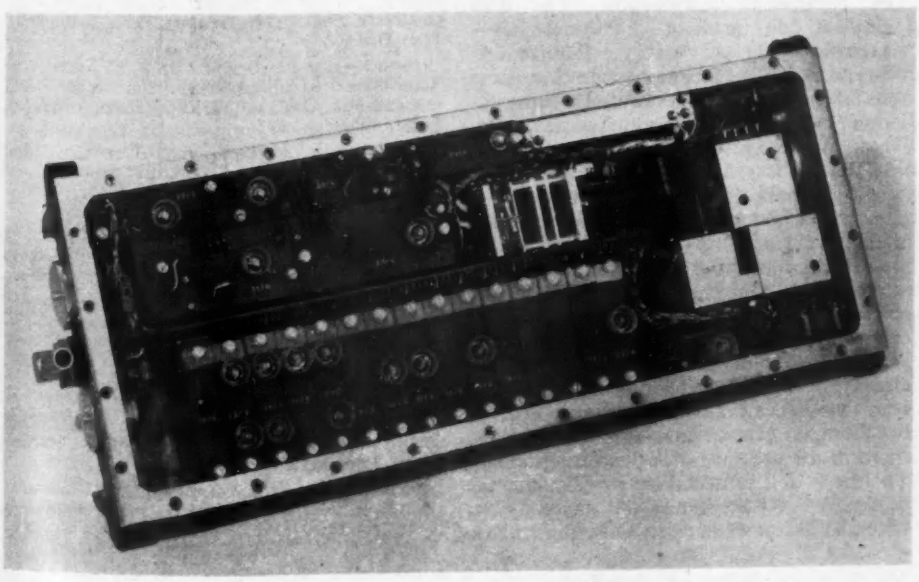


Fig. 3—Experimental missile guidance equipment which has achieved a high degree of economy in power requirements by the use of transistors—G.E.C.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ROAD SAFETY

SIR,—Allow me to say that I had observed that pedestrians are not allowed on railway tracks, and also that this has no bearing whatsoever on the matter of road accidents, since there is no analogy between rail and road safety. To say that " by far the best means of preventing accidents is to reduce the opportunities for anyone to make a mistake " in this context is, to say the least, remarkable. To prevent burglary, possess nothing. We must go faster, so you must be removed from our path. Perhaps you have not noted that the Hertfordshire County Council wishes to prohibit cyclists and pedestrians from a perfectly ordinary road ? The number of road accidents is annually so great that I query whether " the majority of those involved in them have never been involved in one before." It seems likely that many people are involved again and again ; perhaps the insurance companies have some statistics.

" Be a better driver."

PETER KNOTTLEY

Cheam, Surrey,
May 13, 1959.

Book Reviews

Solid Propellant and Exothermic Compositions. By JAMES TAYLOR. Geo. Newnes, Ltd., Tower House, Southampton Street, London, W.C.2. Price 25s.

THIS is a book written by a chemist on a fundamentally chemical subject, but the approach has been mainly along practical lines with as much emphasis on applications as on the theory of reactions. These applications are of great interest to the engineer and cover a much wider field than most people realise. The warlike uses such as explosives and gun or rocket propellants are well known, but the more peaceful uses cover a host of jobs ranging from dispersion of insecticides to the winning of coal.

Much of the material on these subjects is gathered from Dr. Taylor's long personal experience in research and development in the Nobel Division Laboratories of I.C.I. and is presented in a simple, easy style. The book suffers in some parts, however, from an uneven level, both technical and editorial. This may be partly due to the number of contributors upon whom the author has called for assistance, but no such excuse is permissible for all the variations in units as, for example, unnecessary changes between °C., °K. and °F., nor for the indecision in spelling " propellant ". On one page alone this word varies half-a-dozen times in as many lines! It seems a pity to spoil good subject matter with such obvious and irritating minor blemishes.

As might be expected, the first part of the book discusses explosives and propellants in a generalised manner and the second part is more specifically devoted to compositions for various definite applications. The first chapter discusses the philosophy of using chemical energy in the service of man and leads into an easy introductory explanation of the typical compounds and their reaction mechanisms. This is followed by a fascinating chapter on the history, manufacture and use of gunpowder. It includes such little-known details as the use of gunpowder to demolish buildings after the Great Fire of London and the fact that more than 60 per cent manufactured to-day is used in safety fuses. This is followed by a discussion on modern explosives and the difference between deflagration and detonation. The former is initiated by a thermal means, such as a flame and the latter by a physical shock. Suitable initiating explosives, their properties and the practical design of detonators are described in simple terms and their use in explosive rivets cited. This section is completed by a chapter on propellants. These are limited to the solid types and their physical characteristics such as rates of burning, heat release and pressure characteristics, although this is one of the chapters where the author has allowed himself a slightly more detailed discussion on thermochemistry. The remainder of the book deals with some of the less energetic (or lower gas temperature) compounds, gasless reactions and other power applications. The first of these was most successful with ammonium nitrite compositions and was used for the Hydrox blasting cartridge. It had the great advantage of producing non-toxic gases and was suitable for use in mines where explosive mixtures might occur. Later developments based on ammonium nitrate and other compounds are also described.

Altogether the book can be recommended as a useful record of the many ways that gas production can be applied. It is not too involved for non-chemists to appreciate, and its technical matter is nicely interwoven with historical interest.

Nouvelle méthode approchée de calcul des couches limites laminaire et turbulente en ecoulement compressible. Cas d'un gradient de pression. Particularités—exemples. By A. WALZ. Publications Scientifiques et Techniques du Ministère de l'Air, No. 336. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Fr.900.

IN No. 309 of the same series the author gave an account of a new approximate method of boundary layer calculation for both laminar and turbulent boundary layers, in the case of compressible flow. Experience has since shown that detailed explanations of the calculating process were required, as well as practical examples. Some of these have already been discussed in the earlier book. Here the scheme of calculation is evolved for the most general case of a compressible fluid, in the presence of a pressure gradient. To this end it is necessary to calculate the thickness of the boundary layer. The practical examples include measurements on a N.A.C.A. profile involving break-away ; the general analysis of break-away as a result of shock waves, and the friction coefficient of a rocket at high speed.

Solution of Problems in Theory of Machine. By S. ANVONER, B.Sc. (Eng.), A.M.I.Mech.E. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, London, W.C.2. Price 35s.

SOLUTIONS of 203 problems taken mostly from London University B.Sc. examinations are presented in this volume, together with a further 285 questions for which only the answers are provided and brief notes on the formulæ needed. These notes should be treated strictly as *aides mémoires*, since the deductions are by no means rigid. For instance, no justification is given for the instruction: " To each of these values of gear revolutions . . . add y revolutions," which appears below a diagram showing an epicyclic train in which the gear axes are at right angles.

It is not claimed, nor is it true, that the solutions are exemplary in the loose sense of the word. For instance, a finite value is given for the reaction between wheel and rail due to a yawing couple developed in a locomotive axle ! The, admittedly tricky, subject of balancing also draws forth examples unlikely to satisfy the examiner: the words " a weight W_2 at radius R_2 diametrically opposite to D, and rotating . . . at twice the crank speed " cannot be said to " describe clearly " any machine in which D is the crankpin.

Books Received

Higher Electrical Engineering. By J. Shepherd, A. H. Morton and L. F. Spence. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, W.C.2. Price 40s.

Electromechanical Energy Conversion. By D. C. White and H. H. Woodson. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 100s.

Les Organes des Systemes Asservis. By M. Pelegrin, J. C. Gille and P. Decaulne. Dunod Editeur, 92, Rue Bonaparte, Paris (6e), France. Price Fr.5.700

Einfuhrung in die Stromungsmaschinen. By M. Adolph. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz, 3, German Federal Republic. Price DM.24.

Nutzenergie Aus Atomkernen. Vol. I. By K. R. Schmidt. Walter de Gruyter and Co., Berlin W 35, Genthiner Strasse 13, German Federal Republic. Price DM.106.

Drop Forging Die Design. By R. C. Jones. The Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey. Price 3s. 6d.

Fundamentals of Radio and Electronics. 2nd Edition. Edited by W. L. Everitt. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 57s. 6d.

Principles and Practice of Radar. Sixth edition. By H. E. Penrose and R. S. H. Boulding. George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 50s.

Turbine Design for Aircraft Engines. By N. C. Breddy. The Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey. Price 3s. 6d.

Transistor Electronics. By A. W. Lo, R. O. Enderes, J. Zawels, F. D. Waldhauer, and Chung-Chih Cheng. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 45s.

Residential and Commercial Air Conditioning. By C. H. Burkhardt. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 70s.

Mechanical Refrigeration. Second edition By N. R. Sparks and C. C. Diilio. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 62s.

Steam Turbine Runaways

By B. WOOD, M.A.

Some recorded steam turbine runaways are listed and studied. It is pointed out that three things must ordinarily occur before a turbo-alternator can be brought to overspeed by steam from the boilers; the normal governor must fail to cut off the steam; an emergency governor must fail to cut off the steam; and the alternator must be tripped from the busbars. It is pointed out that certain recent runaways were caused by the unnecessary tripping of the alternator from the busbars. The moral is drawn that no machine should be tripped electrically so long as it is carrying significant load; and a protective electric circuit is described which would insure against it.

STEAM turbo-alternator runaways have been known since the earliest days, but are happily a rare event. Below is a list of serious runaways known to the writer. There have doubtless been others which have not received publicity as well as numerous "near misses" where, through good luck, nothing serious actually happened. It is not practicable to design steam turbines to withstand the highest speed to which they can rise. Instead, reliance is placed on protective devices to prevent overspeeding. Hence failure of these devices to function is likely to result in a spectacular smash and possibly loss of life. Hydraulic turbines, on the other hand, are always designed to withstand the full overspeed possible. It will be appreciated that because of the vital importance of avoiding runaways, two independent lines of defence against them are always provided. There are thus three things which must occur in order for a turbo-alternator to be brought to overspeed by steam from the boilers:

(1) The normal governor must fail to cut off steam;

(2) The emergency governor must fail to cut off steam.

(3) The alternator must be tripped from the busbars (subject to special exceptions discussed later).

Some Recorded Steam Turbine Runaways

Reference No.	Plant	Year	Output (MW)	Result	Cause
1	Calder Hall	1958	23	Total wreck	Crash trip button actuated when valves stuck with shot
2	Uskmouth	1956	60	Total wreck	Circuit breaker caused to trip when pilot valves stuck with corrosion product in oil
3	Kimberley, South Africa	1954	3	Partial wreck	Circuit breaker tripped on feeder fault. Valves evidently partly stuck
4	Port Kembla, Australia ...	1952	15	Partial wreck	Severe boiler priming; driver tripped mechanical release then emergency shut-down button which tripped breaker. Valves stuck
5	Philip Sporn, U.S.A. ...	1952	150 (2 line)	Damage slight: l.p. line 40–50 per cent o/s	Bus fault trip. Steam return from feed heaters
6	Newcastle Station, Pennsylvania	1954	100	Damage slight, 50 per cent o/s	Accidental trip: steam return from open heater
7	Diepedalle, France	1951	50	Total wreck	Alternator rotor failure followed by shearing of coupling and turbine overspeed
8	Venezuela	1949	7·5	Damage slight	Circuit breaker trip. Valves stuck due to deposits in steam
9	Gennevilliers, France ...	1945	40	Entire engine-room destroyed	Circuit breaker tripped manually on overload. Both valves evidently stuck
10	Deptford West...	1934	30	Blades shed	Machine tripped by overload relay
11	South Wales	1933	5	Total wreck	Machine alone on system. Load went off. Both pilot and main valves stuck
12	State Line, U.S.A.	1929	208 (3 line)	Damage slight on machine Some consequential damage on C.W. system	Bus fault tripped one l.p. machine which ran away from stored steam in reheater. Intercept valve failed to close
13	Amsterdam, Holland ...	1925	6	Machine damaged	Valves stuck by dirt and deposits

Standard Precautions

It will be clear that with a normal speed governor working and properly controlling the throttle valve (or equivalent), easing off load slowly even on a set supplying its own independent system, would cause a speed rise of less than 4 per cent. If, however, load is thrown off suddenly, the momentary rise of speed will be higher even when the governor is functioning correctly. It is required to be within the setting of the emergency governor, which is 10 per cent (±1) according to British Standard and other national standards. If the normal governor fails to hold the speed, the emergency governor then should function at about 10 per cent overspeed, causing a separate stop valve—the emergency valve—to close and shut off steam. A slight further overshoot determined by the amount of steam passing the emergency stop valve before it closes fully is inevitable. This might be possibly a further 2 per cent. Turbines and high speed alternators are overspeed-tested at the manufacturers' works to prove they are safe at 15 per cent overspeed, and 25 per cent respectively (in some countries 20 per cent).

It will also be clear that ordinarily no overspeed can occur so long as a machine stays coupled to the electric system, since the alternator locks the machine in synchronism. Hence tripping of the circuit breaker by hand (reprehensible) or on spurious or genuine fault or overload is a necessary ingredient in most runaways. Serious overspeed will not occur ordinarily even if synchronism is lost since, if the busbar voltage is maintained from another source, a machine can run as an induction generator with only a few per cent rise of speed. Overspeed without tripping out can, however, occur exceptionally, e.g. where a machine is alone on the bars, but this is a rare condition on public supply networks to-day. It is, however, possible on private networks. Runaway can then occur through reduction of load (in the presence of defects 1 and 2), as did occur in case 11 cited. It can also happen that a system becomes split suddenly leaving too little load on some machines. In this case all governors should close valves on underloaded machines and, even if one fails to do so, the other machines will act as a brake. The situation can become rather awkward where there are both hydraulic and steam turbo-alternators on the same system, but no case of a smash due to this cause is recorded. A three-phase fault on the machine or even on the busbars also short circuits the load and effectively, therefore, deprives the machine of restraint from the system but this also has never caused a runaway yet, presumably because in the past such faults have been a rarity.

Stored Steam

Until the risk was sufficiently appreciated, some runaways (e.g. 5 and 6 mentioned and also one recent one in the U.S.A.) occurred even with the governor valve and emergency valves closed because of stored steam entering the turbine from elsewhere. The two sources of stored steam are:

(1) The feed heaters.

(2) The reheater circuit.

Nowadays these dangers are provided against by non-return valves or governor-operated servo valves in the feed heater lines, and by intercept valves (sometimes also by-pass valves) before the re-entry point of reheated steam into the turbine. It is probable that normal non-return valves in feed heater lines offer much less protection than commonly believed. They convey an illusion of safety, but unless they are either servo-operated from the governor, as in new machines in the U.S.A., or at least servo-tripped also by the governor, it is possible, especially when sticking of the spindle develops, that they will not encounter sufficient torque to throw them over from their open positions until too late. Although there was not until a few weeks ago any authentic record of a machine being destroyed by steam produced by the feed heaters, the danger is not merely a theoretical one, since the runaway to 50 per cent overspeed of the l.p. line of a 150MW set in 1952 at Philip Sporn station (case 5) was attributed to this cause. The latest case in the U.S.A. (not yet fully reported) seems to have been more destructive. The risk becomes more serious as machine inertias per unit of output are being reduced by such things as inner-cooling of alternators. It is clear that when the governor valve closes, the pressure at all points in the turbine tends to fall to vacuum. The water in the feed heaters which was in equilibrium with the steam in them, i.e. a little below the temperature corresponding to the previous pressure at the bleed belt, now finds itself at too high a temperature for the pressure. It thus behaves in the same way as water in a steam accumulator and starts to evaporate. The amount of flash steam is proportional to the drop in temperature, each 10 deg. Fah. drop will produce 1 per cent flash steam if no other heat is removed. The prospective potential energy made available in the water with falling pressure can thus be calculated. However, heat is also being removed from the water in the feed heaters by condensate, so long as any is passing. The exact behaviour, accordingly, depends on how much water is stored in the condenser or surge tank and how much in the feed heaters themselves. The danger is less the greater the amount of condensate stored, and higher the larger the amount of water lying in the bottoms of the heaters. In general, the higher temperature

heaters are the only ones which call for any precautions, because only from these is the steam fairly efficiently utilised by being produced at a fairly high pressure and passing through a large number of stages. The de-aerator heater is more dangerous than its mere position would indicate, because of the large store of water in it. Also, being an open heater, it has no cooling from tubes, but the condensate pumped in will act in the same way as it drops in temperature by reason of falling pressure of each low pressure heater.

As regards stored steam in reheaters, some trouble occurred at North Tees—the first full-scale reheat station. Intercept valves to prevent re-entry of reheated steam into the turbine date from that time. The danger was underlined when one line of a three-line 208MW reheat set at State Line ran away in 1929. The machine did not disintegrate, but the blades were stretched and some incidental damage resulted from the overspeed of auxiliaries supplied from the shaft auxiliary alternator. On the great swing-back to reheat in the U.S.A. in 1950, intercept valves were found to be somewhat unreliable at temperatures of 950 deg. Fah. and upward because of so-called blue blush on valve spindles, which was really a layer of magnetic iron oxide causing an increase of diameter. The result of one or two scares by events which did not lead to smashes, was the introduction of double intercept valves, two in series, and the substitution in the U.S.A. of chromium-plated for nitrided steel spindles. The first set of valves are caused to start to close by the normal governor if the speed rises by about 2 per cent, and the second set are tripped by the overspeed governor at the usual 10 per cent. It is now usual to duplicate the valves, i.e. to provide two parallel sets, so that each can be "exercised" when the machine is doing fairly heavy load to prove that they are in working condition, without interfering with service. It has for a long time been fairly usual to duplicate the fly-bolt and sometimes the plunger that this actuates, and in some machines it is possible to check behaviour by causing the fly-bolt to operate at normal speed by pumping oil in behind it.

Recent Runaways

The runaways at Uskmouth, 1956, and Calder Hall "B," 1958, both involved failure to close both main and governor valves, though for different reasons. At Uskmouth the oil servo system contained magnetic oxide of iron as a corrosion product from the ingress of salty water. This appears to have immobilised trip plungers and oil servo valves of both main and emergency governors. At Calder Hall the same result was brought about through shot (used for shot-blasting the outside of the boiler and superheater elements) entering the clearance space round the main or tail spindles of main and emergency valves. The shot had evidently got inside the elements inadvertently through unplugged ends.

These are both new causes of smashes, unless the runaway mentioned in case 11 in 1933 (never explained) was attributable to the same cause as at Uskmouth. Cleaning shot has come through pipes before and, no doubt, will do again, and other foreign matter, such as water, silica, dirt, scale, welding beads and objects left inadvertently or hidden in pipes, have also been known to jam valves. A case is recorded where a whole coil of new rope had been placed in a pipe (probably with a view to theft) which had apparently then been welded up by another shift. Objects not infrequently manage to go through the meshes in strainers or knock holes in them. In a recent case a runaway (narrowly averted) could have occurred by reason of the perforated strainers surrounding the valves and intended to keep out foreign matter themselves collapsing and jamming the valves. Silica deposits are a particularly dangerous cause because they may be transparent and have an affinity for steel. The use of higher steam pressures and temperatures has led to greater purity of steam and less priming but, nevertheless, sticking of valves due to deposits still occurs and water coming over as in case 4 can cause distortion of the spindle.

Hence, experience shows that jamming of valves is not an uncommon happening and, contrary to what might be expected, a single cause can quite often jam or damage both main and emergency valves. This is particularly likely if the two valves are alike, i.e. of the same form or style. A valve does not need to be held very far open to pass enough steam to run away a set which has tripped out. Not infrequently the valves are found fully closed after a smash but the conclusion is inevitable that they must have delayed closing until too late and only closed finally because of the heavy vibration produced as the machine broke up. Accordingly, it is possible to lay down that the first major recommendation in design is that the main and emergency valves should be designed to be free from any obvious feature that might cause sticking and that they should be different. It is hardly necessary to mention as absolutely impermissible the dependence of both valves on a common link unless this fails to safety. The second requirement is that the valve spindle packing, which is clearly a vulnerable feature, should be loose on the emergency valve. The way that this has been met on all American and certain

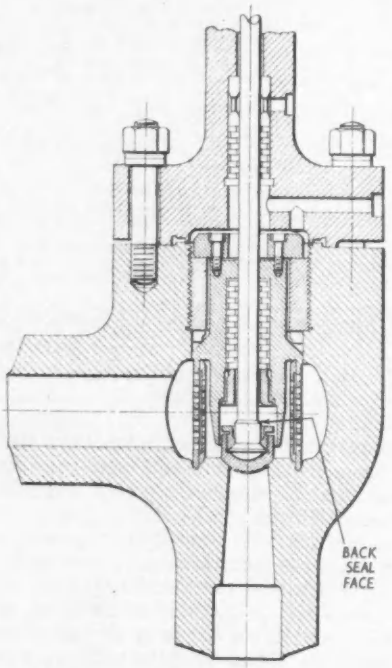


Fig. 1—American design of high pressure emergency valve

Continental and British machines for some years is the so-called back seal, Figs. 1 and 2. The emergency valve is of the mushroom type and for lower pressures can be as simple as that shown in Fig. 2. In its normal full open position the clearance space round the spindle is sealed by a face in the back of the mushroom co-operating with one on the bonnet. Thus, significant leakage along the spindle is prevented, and the packing can therefore be much looser than would be tolerable if it had to provide a seal. This precludes risk of jamming because of spindle growth or external dirt in the clearance space. It cuts off this space from normal communication with the steam, and hence foreign matter, pipe scale or deposits from the steam, cannot obtain access during normal service. Such a valve calls only for a very simple latching mechanism. It does not

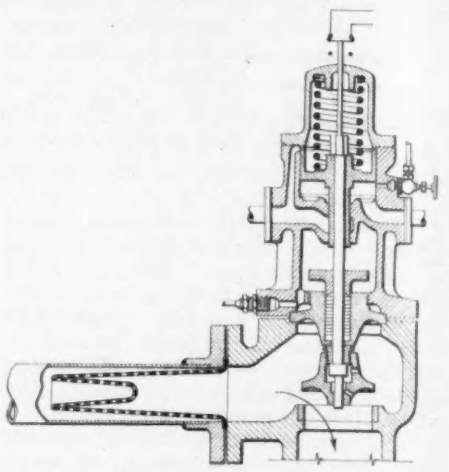


Fig. 2—Continental design of emergency valve

preclude all types of failure, e.g. those connected with the oil system, but where this type of emergency valve has been used there has been no recorded smash. Moreover, though oil has the drawback of high viscosity, it remains, because of its lubricating properties, the most generally satisfactory latching medium. Air, steam or some other gas could give more rapid release. Even with the largest vent considered practical, the closing time of an oil servo valve may be 0·15 second or more.

Actual Cause of Smash

While seizing of both the governor and emergency valve should be prevented by whatever foresight and skill the designer can call on and by adequate checking and maintenance by the operator, it does not immediately result in a runaway, but only represents a potentially dangerous situation. The third ingredient called for to cause inadmissible speed rise is the electrical tripping of the machine off the bars. At Uskmouth this was done by automatic interlocks when the exciter driving motor was tripped out by mistake for that of the next machine. This was interpreted by the protective gear as a fault condition, and the main circuit breaker was automatically opened. Hence the Uskmouth smash was caused by the unnecessary operation of the protective system and if this had not been fitted or had failed to operate, the machine would have continued to run as an induction generator with a speed rise of about 5 per cent, and would not have been any the worse. It could have been shut down in time by closing the hand-operated stop valve. Similarly, at Calder Hall the operator, having received certain indications, operated the crash shut down button on the set, which in accordance with conventional practice immediately tripped the circuit breaker. Had it been possible to delay the tripping of the circuit breaker until the steam was known to have been shut off, e.g. by shutting down the reactor, the smash would not have occurred. This analysis of two recent smashes enables us to lay down the basic prescription to avoid runaways, which is simply that *no machine shall be tripped electrically so long as it is carrying significant load.* In the old days,

when the operator was on a gallery in the engine-room, no one would have thought of doing anything else. Case 10 drew attention to the danger of overload relays and caused them to be immobilised generally throughout the country. The recent crop of smashes are the consequence of the recent fashion for push-button operation and a lack of discrimination among those responsible for the design of the protective gear. In youth one is liable to be carried away by the ability to devise electrical circuits to do this and that and to ignore the maturer view that it is necessary to study the job as a whole, not a mere part of it. Co-ordination of electrical and mechanical protection is advantageous ; it is unco-ordinated protection which is evidently dangerous. Thus, it is beneficial to employ a lost load relay which will cause the governor valve to start to close without waiting for the speed rise to bring this about. It is also right and proper that when the electrical emergency trip button on an alternator is operated, it should pass a simultaneous impulse to release the governor latching oil pressure. This can do no harm and adds an element of security in that steam is immediately shut off without overspeed so long as the governor valves respond. The converse is, however, not true. When the mechanical trip knob on the machine is tripped, it is not advisable that the electrical end should be simultaneously intertripped. The worst that can happen without intertrip is that the set continues to motor if no one does anything about it. The consequence of intertripping may be that the set goes through the roof, since the valves may fail to close and the electrical tie is no longer available to hold the speed down. We have to conclude that in the past incipient runaways were often avoided by the separation of the mechanical and electrical trips.

Furthermore, it must be rare for the governor to develop a sudden serious jam. More usually the tendency not to respond to the speeder motor via the servo mechanism must take time to develop. An observant operator thus has warning of something at fault before the final disaster occurs. The second prescription is accordingly that any apparent disinclination of the governor to respond to the speeder motor should be recorded and reported, so that the machine can be got out of service for investigation as soon as possible.

Positive Means of Preventing Runaways

While it is probably impossible to foresee every cause of a runaway, it appears that those of the classical type above described can be precluded by fairly simple means which take the matter out of the hands of the operator. It has been seen that the criterion of danger in tripping the breaker by hand or automatically is that the machine is generating significant load. This can be discovered either by a wattmeter or by the position of the valves. All that is required, therefore, is that any tripping impulse to the breaker should be blocked if either a wattmetric relay indicates significant load, or a contact on main or governor valve shows that this is not in the almost closed position* (see Fig. 3).

It will be clear that in healthy conditions, when the valves respond practically instantaneously, tripping of the mechanical trip knob or of the electrical emergency button (which also clears the mechanical end), will result in the load falling to zero very quickly and hence the trip impulse to the circuit breaker will be passed through with a delay so short as not to be noticed. (Electrical fault trip impulses should also be arranged to operate the mechanical trip gear direct, as does the electrical emergency trip button.)

If, however, the governor valve fails to close, the load will stay on and the tripping impulse to the circuit breaker will be blocked, so runaway will be avoided. According to Fig. 3, an alarm then sounds, warning the operator that he must shut the isolating valve. In healthy conditions the alarm will give a short pip during the fraction of a second required for the valves to close, thus indicating that everything is working correctly.

The operator is left free to trip the machine at his own discretion, though he will, of course, be warned to ascertain that it is not doing load except in acceptance tests (and occasionally thereafter from time to time) when it is necessary to test the main and overspeed governors by actually throwing off load. This is legitimate so long as suitable precautions have been taken, such as checking that the main and overspeed governors have been " exercised " immediately before and are in operating condition.

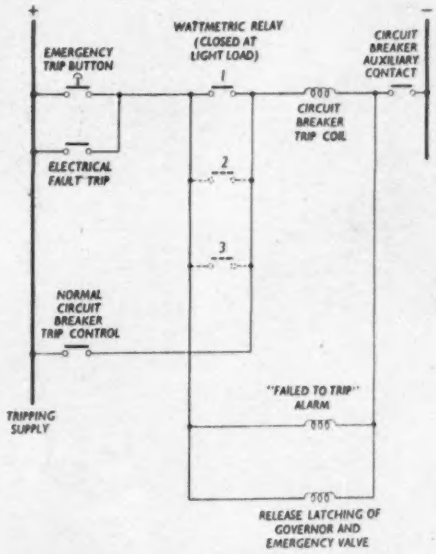


Diagram shows at 1, 2 and 3, three contacts, any one of which will suffice.

2 Governor valve contact (closed when valve closed).
3 Emergency valve contact (closed when valve closed).

Fig. 3—Protective circuit against runaway

It also may be objected that if an electrical fault develops in the machine, the proposed protective gear will delay the clearance. It is true that if the valves fail to close, the fault will not be cleared until the operator closes the isolating valve, and by then considerable fault damage could occur in the alternator. However, this must be regarded as the lesser of two evils. It is more important to save the machine from runaway. The additional delay of a fraction of a second in clearing the machine when the valves correctly respond is a minor drawback by comparison. The protection of the electrical part of the machine cannot be regarded as a purely electrical matter. However, if desired, an exception can be made in favour of certain special kinds of electrical fault tripping impulses by passing these direct to the circuit breaker on the ground that the damage likely to result from interfering with or delaying tripping exceeds that due to risk of mechanical bursting. As mentioned earlier, a three-phase fault in the machine or busbars may relieve the machine of load, hence if a wattmetric relay is used, the tripping impulse will not be intercepted. However, in this case it makes no difference and a smash cannot be averted. The only remedy is to try to ensure immunity against such faults.

In addition to the connection proposed above, it appears possible to obtain still further security against runaway by breaking the vacuum. In case 3 listed (and others) the damage was limited because before the speed had risen sufficiently to burst the alternator, the last row turbine blades came adrift and went through the exhaust hood. The speed rise was thus arrested—an example of inadvertent vacuum breaking. It appears that to fit a vacuum breaker and to operate it from the overspeed bolt, would also provide added security at low cost. Though this is stated by one American maker not to be much help, it was formerly common and is done by one Swiss maker. It may be expected to become normal practice once more in view of the trend to reduced flywheel effect already mentioned, which demands augmentation of braking to limit the rate of speed rise. The consequent sudden change of end thrust in a machine with an odd number of exhausts is a drawback which has to be weighed.

General Design

It will be appreciated that lost load relays or acceleration governors which give the governor advance warning of an impending speed rise benefit only fair weather behaviour and are not therefore discussed. The same applies to other features which lead to faster response, such as use of higher servo oil pressures or higher speed flyballs or improved forms of speed detector. In runaway conditions the main governor must have failed to respond and hence improved speed of response is irrelevant, though, of course, this is valuable from other points of view.

Application to Other Prime Movers

While steam turbines have been mentioned so far, it should be appreciated that reciprocating steam engines, diesel engines and gas turbines are equally vulnerable and liable to runaway. A diesel depends entirely on its governor for stability, since if this sticks a substantially constant quantity of oil will be fed per stroke and hence air and fuel will increase roughly proportional to rising speed. The same applies to a gas turbine if it drives its own fuel pump and own air compressor. A recent case is reported of a diesel which ran away and became a total loss by consuming lubricating oil lying in the inlet manifold. Steam engine runaways caused by valves sticking due to deposits from the steam are not uncommon.

Summary

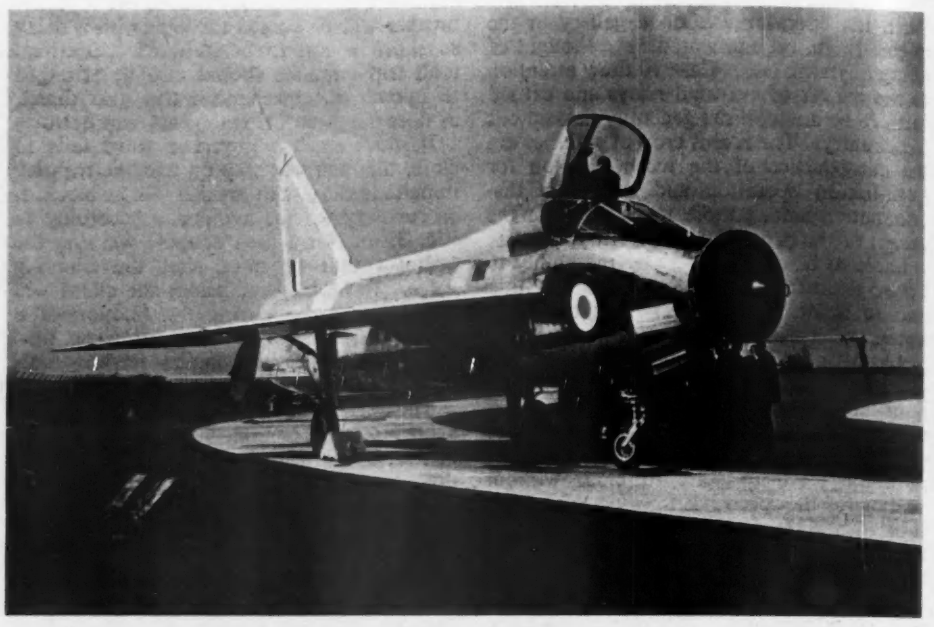
Ordinarily three independent things are necessary to cause most runaways, viz. failure of main governor, of emergency governor and tripping of the circuit breaker. Two recent spectacular runaways in England have occurred through the same cause, viz. unnecessary tripping of the circuit breaker on load when both main and emergency valves were unable to close. Both smashes could have been averted by a simple protective connection described which prevents inadmissible on-load tripping by protective devices and which can be applied to all prime movers. A better form of emergency valve recommended is not so subject to jamming. A vacuum breaker operated by the overspeed trip will add further security.

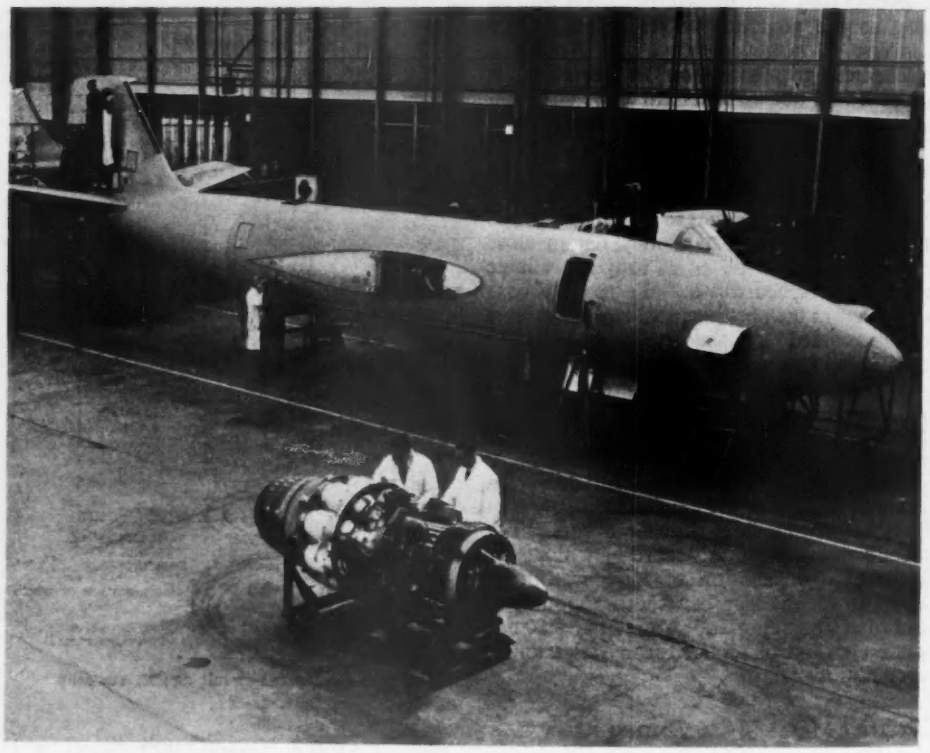
* Patent applied for.

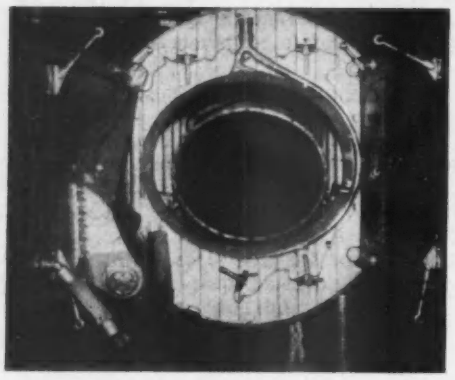
Twin-Jet Aircraft

A two-seat version of the "Lightning" fighter, previously designated the English Electric "P.11," made its first flight on May 6 : it was airborne for half an hour and attained supersonic speed. It is stated that the progress made with this version, which is in production in parallel with the single-seater, will ensure that trainers will be available for pilot conversion at an early stage in the operational life of the "Lightning." The company's chief test pilot reported after the first flight that the two-seater handled as well as, if not better than, the single-seater ; since the fighter is temperature (t.a.s.) limited, it would be expected that the performance would be markedly inferior only in rate of climb. The first two-seat "Lightning" is seen RIGHT : it is intended to carry full operational equipment, although the nose cone does not appear to be dielectric. Notice the bulges to carry air past the cockpit to the upper engine ; the wing is built in one piece from tip to tip.

On May 13, 1949, another two-seater with twin "Avon" engines made its first flight, the prototype "Canberra." Believing that it is virtually unprecedented for an aircraft to be in production for so long, the English Electric Company celebrated the tenth year of "Canberra" flying at their Samlesbury aerodrome. The BOTTOM photograph shows a newly completed aircraft taxying out for its first flight test ; other new and rebuilt aircraft surround it. RIGHT is one of the later versions, a Mk. VIII with offset cockpit canopy, under construction, with an "Avon" awaiting installation in the foreground. The design is dominated by the single spar wing construction, which includes transport joints outside the nacelles : the engines are virtually buried, the size of the nacelles being dictated by the spar depth, and the illustration BELOW shows how the tail pipe is flattened where it passes through the spar. On the left (inboard) side of the engine bay can be seen the pivot of the inwards-retracting main undercarriage. One version of the "Canberra," the T.XI, is equipped to train "Lightning" crews on the "Airpass" radar and also for active countermeasures, leading to the speculation that the new aircraft might also be able to perform the latter role.

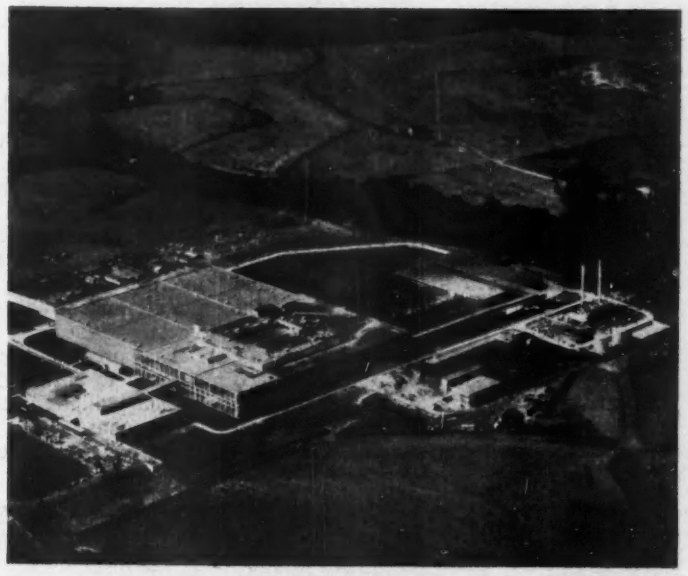






Heinz Factory at Kitt Green

Yesterday, May 21, marked the official opening of the new factory built for H. J. Heinz Company, Ltd., at Kitt Green, near Wigan. The site has an area of about 150 acres, of which only a small part has been developed. Planning has been based on a production of 122,000 tons per year and provision made for expanding facilities to raise production to 250,000 tons per year. The accompanying aerial view of the factory shows the main production building in the centre with the employee services building to the left and the can-making plant to the right.



EXPANSION of demand, commercial developments, the introduction of new manufacturing techniques and the need to evolve new products, coupled with the knowledge that the leasehold of the Standish factory could not be acquired, influenced H. J. Heinz Company, Ltd., to build a new factory at Kitt Green, near Wigan. The site for the project covers an area of approximately 150 acres, of which a considerable part was unsuitable for building purposes owing to there being old coal mines beneath. A further 8 acres forming the bank to a stream on one of the boundaries were too steep to be used for building purposes.

The practical part of the site suitable for development is on the brow of a hill and even here there were difficulties in that there was a considerable gradient of about 1 in 40 to contend with. This, in conjunction with the company's specified requirements, led to the adoption of a particular form of basic circulation, while the size of the project allied to certain provisions for expansion favoured consideration being given to a two-storey concept. Planning had to satisfy area requirements for storage and production and for a labour force operating on a shift system, while the production layout had to permit of the maximum flexibility to suit the widely varying outputs of the many processes and also any future changes in the production machinery. Although details vary, the processes are similar and in general the sequence is preparation, cooking, can-filling, sterilising, packing and labelling and, finally, despatch. As designed and built, the two-storey arrangement has been adopted, the upper working level serving unloading, storing, preparing and cooking, while the low level caters for filling, sterilising, packing, warehousing and ramped roads provide access for the delivery of raw materials and the despatch of finished products. The ramped roads have Pyrotenax cables embedded in the surface layer so that the surface can be warmed to prevent the formation of ice and other dangerous conditions for road vehicles. There is a mezzanine floor between the production levels which serves as a circulation space for personnel and the housing of the services. By means of a covered bridge, this floor is linked with the employee services building and the main entrance to the factory. To the north of the production building, and separated from it by an area reserved for expansion, is the can-making factory which feeds the cans via an overhead gantry to the mezzanine floor, ready to be gravity fed to the filling lines.

The main building covers an area of 6½ acres and has a volume of about 15,000,000 cubic feet and the corresponding figures for the employee services building are 1 acre and about 1,300,000 cubic feet respectively, while the can-making building and workshops account for about 1½ acres. The main building is of steel frame construction with floor loadings ranging from 900 lb per square foot in the warehouse to 475 lb in the raw materials area and 350 lb in the production section. The employee services building is of reinforced concrete frame with a floor loading of 80 lb per square foot. The production building is designed on the open plan system without light wells and is therefore completely mechanically ventilated through suitable supply and exhaust ducts with the relationship between supply and exhaust and also the number of air changes per hour varied to suit requirements, the total capacity being 1,000,000 cubic feet per minute. The heating system is designed to maintain an internal temperature of 65 deg. Fah., with the outside temperature at 30 deg. Fah. and in the production section this is achieved by steam to air heater batteries assisted by low pressure hot water radiators, convectors and unit heaters and by steam to large floor pattern unit heaters in the warehouse and raw material sections. The total capacity of the heating system is 85,000,000 B.Th.U. per hour and the heat source is steam generated at 150 lb per square inch and reduced to 65 lb per square inch.

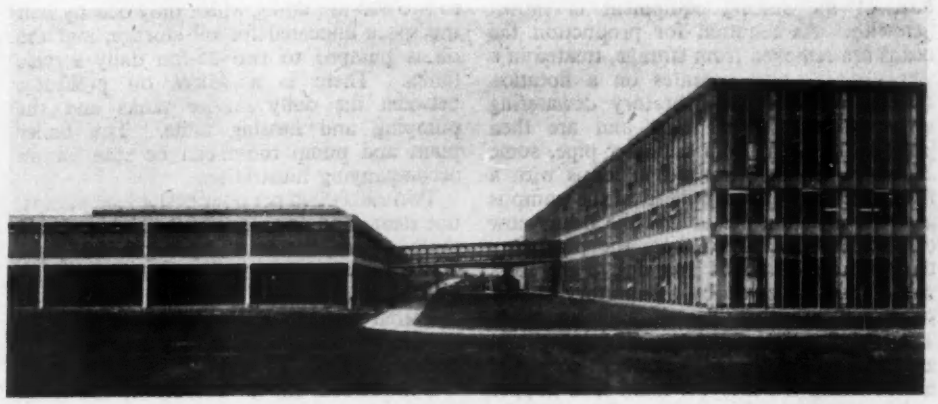
Some 8000 tons of structural steel and 2000 tons of reinforced steel have been used in the construction and the foundations consist of cast in-situ bulb-footed piles, each of which carries about 45 tons. We illustrate below the main production building and employee services building and the connecting personnel bridge.

Production Lines

When fully operational, it is expected that the factory will have a production level of 122,000 tons per year and that this can be raised to 250,000 tons per year when the area reserved for expansion is developed. Accommodation is provided for 1500 men, of whom 500 work at night, and about 500 women engaged solely on day work.

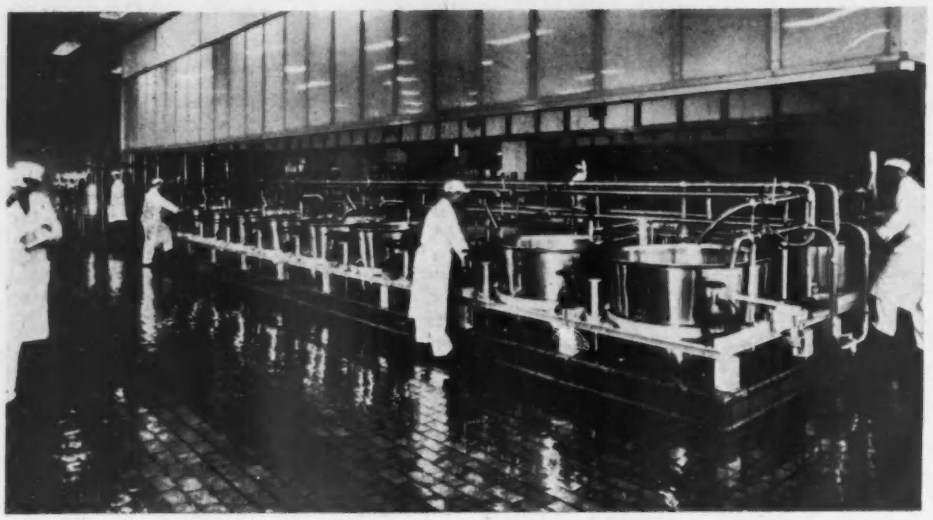
The raw materials, which are supplied under contract from farms, are delivered by road to the factory and up a ramp road to the canopy for unloading to the raw materials store. Here the vegetables are inspected and bagged and some are placed in a cool store, which is maintained at 32 deg. to 35 deg. Fah., while the meat goes to cold rooms maintained at 10 deg. to 12 deg. Fah. by refrigerator plant supplied by J. and E. Hall, Ltd. As and when required, meat is forwarded to the meat room where it is cut up in " hydroslicers," pressure cooked in steam retorts, then diced and passed on to the soup kettles. Chickens pass through a thawing out tank and are cooked before being hand stripped and diced ready for soup making. The vegetables are prepared by passing over shakers, to remove dirt, followed by a coarse and first wash and abrasive peeling and then to the hand trimming tables from which they are conveyed to storage ready for dicing. Handling is by means of screw elevators and a series of belt conveyors and all movement is sequence controlled.

For the making of soup in the batch



A personnel bridge connecting the employee services building (on the left) with the production building

system a mix of either meat or vegetables is made up and delivered to soup kettles, which are steam jacketed, and some of which we illustrate. After cooking, the contents are dropped to a finisher or straight tube to a stock tank and then through strainers to the filling line. Soup is also made in the continuous process and here the ingredients are placed in a cold mix tank, having twin stirrers, and afterwards pass through a steam injection system for cooking, and thence to a stock tank and through a sieve to the filling line. On the lower floor of the production building cans, delivered by conveyors from the can-making plant, are sterilised in temperature controlled hot water and then filled and the top cap fitted. The filled cans are washed and conveyed to the sterilising section where they



Battery of soup kettles

are loaded into rectangular baskets which are then placed in automatically controlled steam sterilising retorts. Later the baskets are unloaded and the cans forwarded to labelling and packing stations and then to a finished goods warehouse. In the sterilising area the loading and unloading is by the Busse system and each labelling machine is designed to handle 600 cans per minute. We include a general view of part of the filling and labelling department.

Beans have an individual production line; they are continuously weighed and pass over a "scalperator" to remove large trash and then are graded in Boby sifters to the size required. They pass through an air stoner and then on to a battery of electronic sorters where the beans are sorted to a colour standard, those accepted being bagged and stored while those discoloured or having other defects are automatically rejected. Part of the sorting equipment is shown herewith. As required for production the beans are removed from storage, treated in a wet stoner, which operates on a flotation system, pass over a vibratory dewatering screen to a blancher tank and are then pumped through a 4in diameter pipe, some 2000ft in length, arranged in loops with a fixed rate of rise. Just ahead of the pump is a steam injection heater and the beans now cooked are discharged from the pipe at a temperature of about 140 deg. Fah. to a wet stoner, followed by a vibratory shaker sieve and are then fed through an oven. They pass over a continuous weigher and are inspected on a vibratory conveyor before being fed into the main feed hopper which supplies the feeding line over a vibratory screen. From the preparation level the beans are gravity fed down to the canning section where the cans are filled and sauce added, the sauce being prepared in a special section in a manner similar to the preparation of soup.

Throughout the production building stringent precautions are taken in the matter of hygiene to ensure that the food is not contaminated in any way. Air supplies are filtered, machines are regularly washed down and the floors and walls cleaned, while the internal design of the building facilitates the attainment of a high standard of cleanliness.

The product itself is being constantly checked to ensure that standards are being maintained. There is a testing panel to check consistency, &c., and samples are forwarded direct to the laboratory by a Lamson tube system so that the product can be tested for acidity, salt level, viscosity and colour; in addition, selected finished goods are subjected to a bacteria test.

Services

Provision of steam for process and other services is by three Babcock and Wilcox oil-fired water-tube boilers, each rated at 50,000 lb per hour at 160 lb per square inch, and designed to burn high viscosity fuel up to 3000 seconds Redwood. The plant has been built in the open, similar to oil refining practice, A fourth boiler is to be built and the area is laid out for the addition of four more boilers should plant extensions so warrant. For each boiler there is a Howden induced draught and a forced draught fan, and to take the boiler gases are two chimneys each 6ft in diameter by 120ft in height. Fuel is delivered by road to two 600-ton tanks, which only occupy half the space allocated for oil storage, and the oil is pumped to two 25-ton daily service tanks. There is a 45kW oil preheater between the daily service tanks and the pumping and heating units. The boiler plant and pump room can be seen in an accompanying illustration.

Two 230,000 lb per hour boiler feed pumps, one steam and one electric, are provided and there is a Permutit hydrogen-ion base exchange water treatment system rated to handle 8000 gallons per hour. Steam is delivered through a 14in diameter main to the factory and the boilers are controlled by Bailey meters.

Compressed air for service in the main building is provided by three "Broomwade" dry cylinder carbon ring compressors each rated to deliver 180 cubic feet per minute of oil free air at 100 lb per square inch.

The factory uses a very large quantity of water for process cooling and washing-down, and located under the employee services building are two storage tanks, each holding 250,000 gallons. Four Worthington-Simpson 800 gallons per minute, two-stage, high-lift centrifugal pumps, one of which is a stand-by, draw the water through a 15in suction and discharge against a head of 120 lb per square inch through a 10in main to the production building. There is space for a fifth pump and the pump motors are pipe-ventilated and insulated to reduce noise. To produce water for washing-down purposes there is a chlorination plant supplied by Wallace and Tiernan, Ltd., which provides chlorinated water in two strengths, namely, 50 p.p.m. for floors and 5 p.p.m. for conveyor sprays, &c. Gas supplies are provided by the North Western Gas Board at 4in water gauge and the pressure is raised to 13in water gauge by two Keith Blackman gas boosters, one working and one stand-by. Each booster has a capacity to handle 15,000 cubic feet per hour and there are arrangements for them to work in parallel, if required, at 25,000 cubic feet per hour.

All the services are piped to a service corridor on the mezzanine floor in the production building—here are to be found piping for process and heating steam, condense, process and domestic hot water, process cold water, chlorinated water, cooling water, compressed air, gas and electrical mains, &c., from which separate branches are led to the individual departments. Reducing valves break down steam pressure to that required for the various processes and both steam and gas are metered for costing purposes.

An extensive heat recovery system, of which we include a diagrammatic arrangement, has been installed in which waste heat is extracted from the water cooling the steam heated sterilising retorts to supply hot water to eight 2750 gallon storage cylinders, from which the water is forwarded to the production area by two 600 gallons per minute pumps at 120 lb per square inch. Water from the cooling tower ponds is pumped to the retorts and then passes by gravity to the hot well, and this water is circulated through three $3{\cdot}75\times10^6$ B.Th.U. per hour low temperature heat exchangers, which it enters at about 118 deg. Fah. and returns to the hot well at about 102 deg. Fah., by three 600 gallons per minute primary pumps at 30 lb per square inch. Two 600 gallons per minute secondary pumps handle water which is raised in temperature to about 100 deg. Fah. in the above heat exchanger and which, therefore, heats the cold water which has been pumped from the intake tanks to a 20,000 gallon storage tank on the roof. The hot water storage cylinders are interconnected with another set of calorifiers having as a primary heating medium flash steam from the main condense tank. For the three 4,000,000 B.Th.U. per hour high temperature heat exchangers there are two 450 gallons per minute pumps.

The retort cooling water system provides for the cooling, sterilising and recirculation of a maximum of 110,000 gallons of water per hour, the actual rate of flow being determined by factory demand and controlled by a venturi meter which automatically cuts the pumps in or out. Three 600 gallons per minute pumps forward the sterile water at 120 lb per square inch to the retorts. Afterwards, as already noted, the water is returned to the hot wells, passes through the heat recovery unit, and is then pumped to the

A section of the filling and labelling department

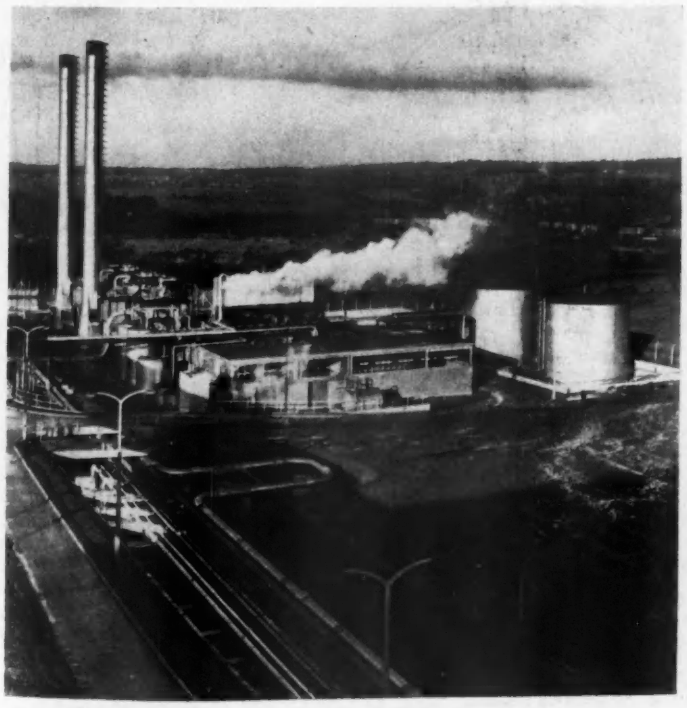
Bean sorting equipment on the upper production floor

top of the reinforced concrete forced draught cooling towers, of which there are eight. In passing down through the towers against an upward flow of air, the water is cooled to about 70 deg. Fah. and is collected in a 35,000 gallon balancing tank, from which it flows through five gravity filters into the clear water tank. The filters are automatic in operation and back washing is initiated on a time control setting instead of on the basis of loss of head. The quantity of the water is maintained by chemical dosing, the plant having good flexibility and adding a coagulant and a correcting dose of lime, as required. Sterilisation of the water is by chlorination equipment which is fitted in duplicate at alternative points in the cooling tower circuit.

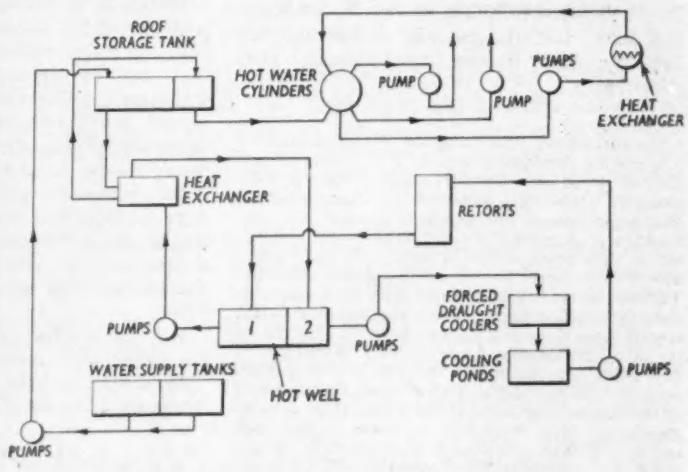
A separate system of sewers collects the trade effluent from the factory and discharges to the north-east corner of the site near the boiler plants. At this point the sewer has a capacity of 624 cubic feet per minute and the flow is divided to pass through two grease traps, one for low flows of about 500,000 gallons per day and the other for the higher flows of approximately 750,000 gallons per day. Next the effluent enters the screening plant, consisting of four screens, two conveyors and elevators and an overhead collecting hopper, into which the screenings are deposited ready for disposal by lorry. Each screen is rated at 40,000 gallons per hour without the vibrator and between 50,000 to 60,000 gallons per hour with vibration. From the screens the effluent passes through a measuring flume to two balancing tanks, each of 125,000 gallons capacity, which control the rate of flow to the trunk sewer, to a maximum of 80,000 gallons per hour, as required by the local authority. A sampling unit is installed at each tank.

Waste from the vegetable preparation room after passing through a disintegrator is discharged via a stainless steel shaft, which is fitted with a spray pipe for cleaning purposes and surmounted by an extractor fan, and a manhole on the ground floor into a sewer which joins the trade effluent sewer. Effluent from the screening plant is recirculated to ensure that the waste will flow, there being two 500 gallons per minute pumps, one being a stand-by, for this purpose.

Mechanical supply and exhaust ventilation systems are installed in the production building and there are five ventilation plant rooms of which No. 3 is located on the roof. In each of rooms Nos. 1 and 2 there are twelve supply and eleven exhaust fans, the total supply capacity per plant room being 125,000 cubic feet per minute. Twenty-four supply fans of 480,000 cubic feet per minute total capacity are located in plant room No. 3 and twenty-nine exhaust fans of similar capacity. In plant room No. 4 are five supply and five exhaust fans, the capacity of each



Boiler plant and pump house



Diagrammatic arrangement of heat recovery system

set of fans being 44,000 cubic feet per minute, while in room No. 5 there are four supply and four exhaust fans of 36,000 cubic feet per minute capacity per set. All the fans are of centrifugal pattern supplied by Keith Blackman, Ltd. In addition, there are twelve axial flow fans for ventilating the various service plant rooms, such as the transformer rooms and sixteen extraction fans over steam hoods. The supply air is filtered in automatic continuous cleaning viscous oil filters. In the can-making plant there are fifteen fans, mainly exhaust, having a total capacity of 60,000 cubic feet per minute.

In the warehouse, heating and ventilation is by jet stream floor pattern unit heaters, provided by Copperad, Ltd., from which air is discharged just below ceiling level and above the stored goods, the air throw being about 100ft to 120ft. The air returns down to lower levels through the pallets to the inlets to the heaters, which are at floor level. Steam for heating purposes is piped at 35 lb per square inch and each heater is thermostatically controlled and rated at 300,000 B.Th.U. per hour. Ducts from roof level provide for fresh air to be added.

Power at 6·6kV is supplied by the North Western Electricity Board to an intake substation equipped with Metropolitan-Vickers oil-immersed switchgear, which feeds two 6·6kV ring mains, one of which supplies three and the other four substations, all equipped by Brush Electrical Engineering Company, Ltd. In these seven substations there are distributed fifteen 500kVA transformers, which supply power at 415V. To meet possible increased demands for power owing to future expansion of the factory provision has been made in each station for the installation of an additional transformer. Three of the substations each supply three distribution points in the main production building. There are a number of 10kVA transformers, which provide power at 110V for portable tools, and the system has earth leakage protection which operates at 10 milliamperes. The lighting fittings in the main production buildings are semi-recessed and are both spray-proof and vermin-proof, and the twin tubes provide lighting at 20 lumens per square foot.

The architect for the project was J. Douglass Mathews and Partners, while G. H. Buckle and Partners were the consultants for the mechanical and electrical work, and John Taylor and Sons were the consultants for drainage, trade effluent and water cooling. Other consultants included Kaylor and Pick, Ltd., Mr. Niels Lisborg, R. T. James and Partners, Mr. A. C. Aston, and A. Boxall and Partners. The general contractor was A. Monk and Co., Ltd., Warrington, and the main sub-contractors were Peirson and Co., Ltd. (structural steelwork), Z. D. Berry and Sons, Ltd. (mechanical ventilation and heating), and Barlow and Young, Ltd. (electrical).

INTERNATIONAL INSTITUTE OF REFRIGERATION.—The first International Congress of Refrigeration was held in Paris in 1908 and shortly afterwards in January, 1909, the International Association of Refrigeration was established and after the first world war became an intergovernmental organisation with headquarters in Paris. To-day, half a century later, there are thirty-five member countries. The general conference defines every four years the main tasks of the Institute while the technical board co-ordinates the scientific and technical activity of the nine International Commissions. A congress is held every four years and the next is arranged for August 19 to 26, 1959, at Copenhagen. Full members of the Institute are Governments but others may be nominated as "Associate Members" who will receive a Bulletin published every two months. Application for Associate Membership should be made to the International Institute of Refrigeration, 177, Boulevarde Malesherbes, Paris 17°.

Modification of "Zeta"

Modifications carried out in 1958 to improve the performance of "Zeta" were described in a paper presented at the recent I.E.E. convention on thermonuclear processes, held in conjunction with the British Nuclear Energy Conference. These modifications consist of the installation of a stainless-steel bellows liner in the torus, ignitron switching and simplification of the pulse circuit, and improved vacuum pumping, stabilising field and diagnostic facilities. Experiments are in progress on the modified machine, known as "Zeta IA." Abstracts from the paper are reproduced here.*

EXPERIENCE with "Zeta" in 1957 showed that it was desirable to improve its performance in both scientific and engineering aspects, and late in that year the design and installation of a number of modifications were undertaken, aimed at the following improvements :

(*a*) Reduction of liner maintenance difficulties.

(*b*) Improvements to the vacuum system to reduce contamination of the discharge.

(*c*) Improvement of the axial field to reduce damage to the liner by arcing and improve stabilisation of the discharge.

(*d*) Circuit modifications to increase the rate of energy input to the discharge and to improve control.

(*e*) Improvement of diagnostic facilities.

LINER SYSTEM REDESIGN

The "Zeta" torus and liner system is described in the paper† by Butt *et al.*[1] Operation at gas currents above 160kA was limited in duration to prevent excessive damage to the liner system, but even then the life of the liner system was short, necessitating costly and time-wasting overhauls. Consideration was therefore given to the use of other materials from which a replacement liner might be manufactured. Dr. P. C. Thonemann had already suggested that a continuous liner of sufficient resistance to ensure that its shunting effect on the discharge was small would inhibit breakdown of the main gaps in the torus body.

Materials testing with a smaller torus[2] had already shown that stainless steel had a shorter conditioning period and a reduced tendency to arc after conditioning than other common materials. The problems were to achieve a sufficiently high resistance and to assemble inside the aluminium torus a second tube which was required to be continuous and insulated from the torus wall.

In "Zeta" the discharge resistance is of the order of 3 milliohms, and it was considered that a liner resistance of 25 milliohms would be satisfactory, resulting in peak liner currents of 120kA at the voltages envisaged, i.e. 3kV per turn. Calculation showed that a simple tube of the required dimensions, fabricated from 15 mil stainless steel sheet, would have a resistance of only 5 milliohms, but it would also be too weak to withstand the pressure differential resulting from vacuum failure.

TABLE I.—*Stainless Steel Liner Resistances*

Temperature, deg. Cent.	Resistance	
	Calculated, ohm	Measured, ohm (accuracy ± 1 per cent)
18	0·020(*a*)	0·020 9(*c*) 0·020 8(*d*)
255	0·025(*b*)	0·026(*c*)

(*a*) Resistivity ρ = 74 microhm-cm.
(*b*) Temperature coefficient of resistance = 0·001 part per deg. Cent.
(*c*) Calculated from 50 c/s input to transformer.
(*d*) Bridge measurement.

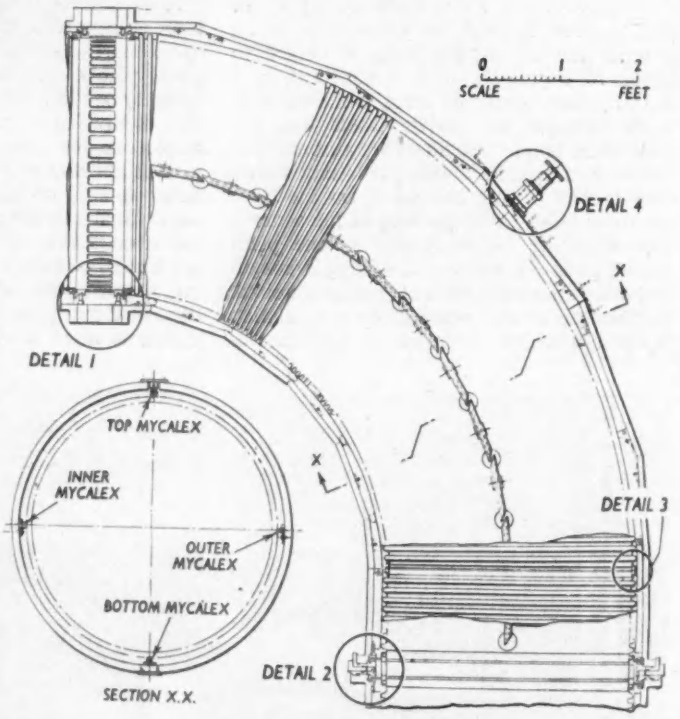


Fig. 1—Constructional features of continuous stainless steel liner system in "Zeta IA"

Both these effects were overcome by corrugating the surface of the tube (two and a half corrugations per inch, each 0·7in deep). The bellows construction simplified bending the straight assemblies to a toroidal shape, while the constant resistance per turn distributed the liner current evenly over the liner cross section. The liner was manufactured by forming and welding techniques developed for pipe expansion joints, suitably adapted to the size and gauge of sheet required (see Fig. 1). Measurements on liner resistance are given in Table I with the calculated figures for comparison.

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* By J. T. D. Mitchell, H. R. Whittle, E. M. Jackson and P. B. Clarke, of the U.K. Atomic Energy Authority Research Establishment.

† THE ENGINEER, May 15, 1959, page 761.

Main Gap and Constructional Joints in the Liner.—The design of the insulated main gap joints in the torus body remained unchanged in principle, although minor alterations have been made to improve the cooling and heat shielding of the polythene insulator. The problem was to make the electrical connection between the two halves of the liner capable of carrying peak liner currents of 120kA under the conditions imposed by the original design, in which each joint is situated in the middle of the 5ft long 5ft diameter core tunnels with no means of access. An assembly with 240 double-contact fingers is used, accurately located in all planes with respect to, but insulated from, the torus body, and able to cater for any creep of the polythene insulation. The polythene insulator withstands the compressive loading of atmospheric pressure acting over the cross section of the torus (see detail 2 in Fig. 2). The contact fingers are of molybdenum, which did not weld to stainless steel on tests carrying pulse currents of 1·5kA per contact. The liner is made in three parts for each quarter torus, and is insulated from the torus body with Mycalex (grade LDS) spacers. Although Mycalex is brittle and easily damaged, it can be worked into the simple shapes required, and has proved satisfactory for use in vacuum at the temperature required.

At the window blocks, slotted stainless steel rings (colanders) (Fig. 1 and detail 1 in Fig. 2) allow for vacuum pumping of the inside of the liner and for direct access to the discharge for experimental (or diagnostic) purposes. The liner is sealed to the torus body at this point to maintain isolation between the main vacuum pumping system and the separate vacuum systems pumping the interspace between the liner and torus.

A port has been provided in each quarter torus for electrodes for pre-ionising the gas and for the insertion of diagnostic equipment. These ports are insulated from the torus but connected to the liner (see detail 4 in Fig. 2).

Liner Temperature and Cooling.—It would be unnecessarily complicated to water-cool the liner directly as had been done in the original design. Furthermore, an improvement in the vacuum base pressure could be achieved if the liner were allowed to run hot, the limit of 400 deg. Cent. being imposed by the Mycalex supports. All the stored energy from the condenser bank (43kW mean power) apart from the primary losses and penetrating radiation (X-rays, neutrons, &c.) is deposited in the liner by direct resistance heating and from the discharge.

To increase the radiation losses, the outer surface of the liner has been oxidised. Calculations based on a stainless steel emissivity of 0·85 and a torus wall inside surface emissivity of 0·3 (approximately) showed that radiation heat transfer from the liner to the torus body would be satisfactory. Furthermore, the liner mass (970 lb for bellows only) is sufficient to limit the calculated temperature rise per pulse to 2·3 deg. Cent. with an input of 0·5 MJ.

Welding of cooling tubes to the torus body would distort the original alignment of the two halves of the torus. Therefore, to cool the torus, aluminium water cooling tubes welded to shaped backing plates have been screwed or riveted to the torus body, between the axial field coil formers, and connected to the original liner cooling system.

Axial Field Exclusion.—The penetration time of the axial field through the stainless steel liner is short (some microseconds). One of the requirements for the stabilisation of the discharge is that only a small fraction of the flux from the interspace between torus and liner should pass through the liner during this discharge.[3] Therefore, $\frac{1}{4}$in diameter copper wire rings were fitted in the bottom of the liner convolutions, increasing the field penetration time to about 7·5 milliseconds, compared with the discharge time of 4–5 milliseconds.

Although the voltage drop between the peak of one convolution and the next could not exceed 2–3V, the individual rings were insulated from the liner to inhibit arcing between the copper and the outside of the liner, which could initiate breakdown of the liner torus insulation. The copper rings were therefore flame sprayed with alumina. Constructional details of the copper rings are shown in Fig. 2.

Liner Manufacture and Assembly.—After initial fabrication and rolling, sections of the liner were oxidised in a muffle furnace. Because it was not found possible to prevent oxidisation of the inside of the liner, the oxide was removed by silica-sand blasting.

Tests on small specimens had been initiated concurrently at Harwell and unfortunately showed that the embedded grains of silica caused excessive arcing, there being no conditioning after 1000 test shots.[2] However, experiments on silica-blasted samples subsequently cleaned in a mixed acid pickle, which reduced the detectable silica on the metal surface to approximately 2μg per square centimetre, showed that conditioning occurred after 200 shots. Therefore all liner sections were pickled, the outer surface being protected by polythene sheet and adhesive tape. This simple measure satisfactorily prevented removal of the outer oxidised layer.

The flange and contact rings are in alignment to within 0·025in on centres and the flanges parallel to within 0·035in. The contact fingers in the liner were tested for wipe and 98 per cent of the contacts have the designed wipe and pressure.

All construction and assembly stages after pickling were carried out using protective clothing, clean tools and equipment, and the parts were protected with polythene sheet at all possible times. Before final assembly, all parts of the torus and liner system were cleaned with ethyl alcohol. These measures were taken to ensure minimum contamination of the discharge channel by grease, &c., which would not be completely removed by outgassing.

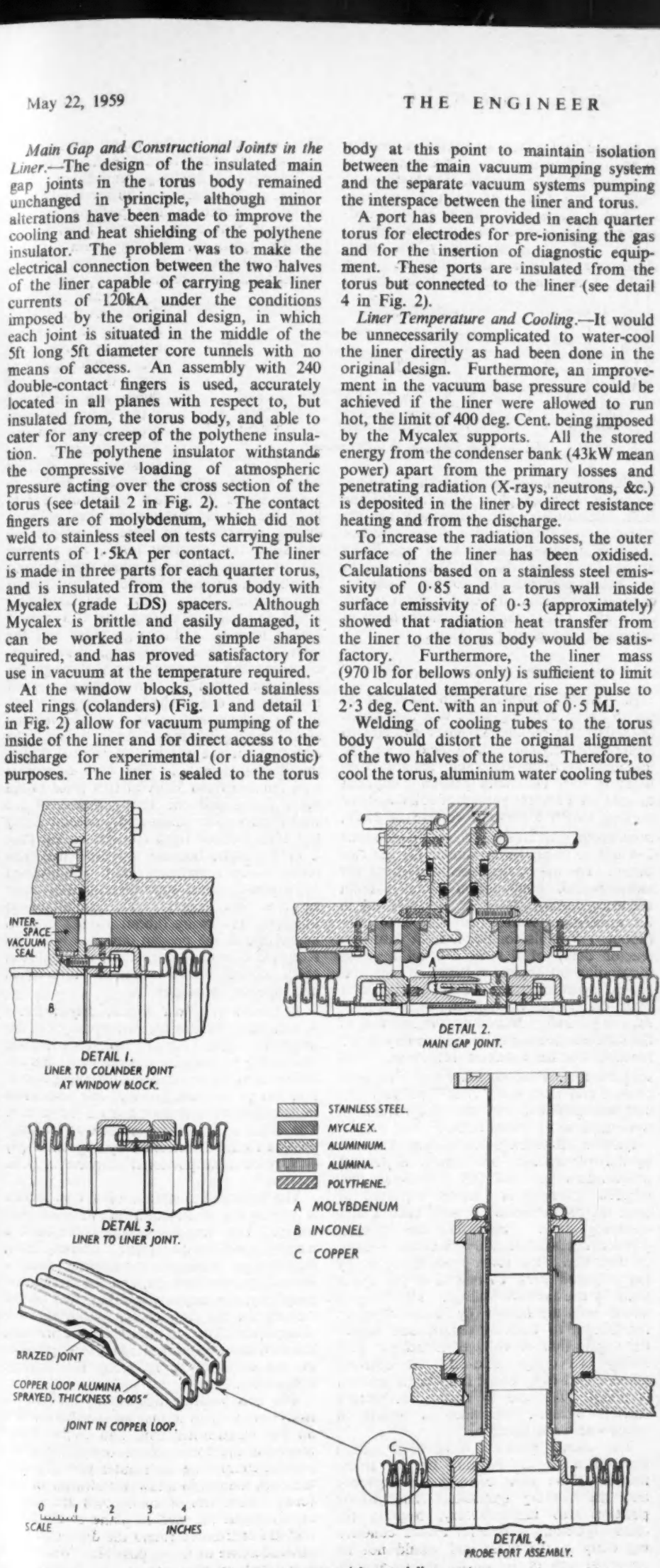

Fig. 2—Details of continuous stainless steel liner system

Improvements to the Vacuum System

In "Zeta IA," constructional difficulties have not allowed full advantage to be taken of the continuous liner system in respect of the vacuum requirements. The liner contact joints at the torus main gaps form a low pumping speed labyrinth rather than an effective seal, and the liner torus seals at the window blocks are not as good as desired, thus lowering the pressure differential across the liner wall. The original liner arrangement involved some 200 rubber O-ring seals in joints in the torus wall, and while the number has been halved in the present assembly, there are still too many, all giving rise to small leaks. For example, vacuum test of a similar torus quadrant without liner mounting seals showed a leak

rate of about 5 millimetre-micron per second, which is nearly two orders of magnitude better than has been achieved on " Zeta IA." While the liquid-nitrogen traps have been improved in design, the traps and a large surface area between them and the liner cannot be heated for outgassing.

Details of Modifications to the Vacuum System.—The pumping arrangement remains as on " Zeta I," i.e. four 14in–9in diffusion pumps for the discharge channel and eight 6in pumps for the torus liner interspace.[4] To improve the torus vacuum base pressure to 10^{-7}mm Hg, guard rings[5] and refrigerated chevron baffles have been fitted to all vacuum pumps and redesigned liquid nitrogen traps to each 14in–9in pump. The liquid-nitrogen traps provide surfaces at or close to liquid nitrogen temperature throughout the pumping passage.

The control scheme has been simplified by the removal of air actuation from all except the fine side valves and the rough pumping line has been removed. The rough pumping must now be done by pumping through the diffusion pumps. This results in a more tedious operating procedure, but the removal of all except essential valves and pipework was considered necessary to obtain the improved base pressure. The use of silicone fluid has been retained.[1, 6]

A large amount of complex equipment is required for investigation of the behaviour of a gas discharge, much of it connected directly to, or inserted in, the discharge channel.[7] The design of this equipment has been modified to ensure the minimum contamination of the discharge.

Vacuum Equipment Tests.—A series of tests were carried out with this modified system to determine the pumping speeds of the system at the window block and torus gap for various gases (nitrogen, deuterium, argon and hydrogen), and the pressure distribution around the torus.

A base pressure of $2\text{–}4\times10^{-7}$mm Hg has been achieved ; the pressure in the liner torus interspace is about four times lower than that in the discharge channel when the latter is at its working pressure of 10^{-4}mm Hg.

Improvement of the Axial Field

Work in 1957 on " Zeta 1 " suggested that the discharge was not uniform, and the inner surfaces of the aluminium liners showed more arcing at the torus gaps and the window blocks than elsewhere. In spite of the fact that the calculated m.m.f per centimetre was correct on the axis of the torus, it was realised and proved that inhomogeneities were present, particularly at the outside of the window blocks and torus gaps. Temporary water-cooled windings fed from a second variable d.c. supply had been installed at these places.

Careful detailed design of the new primary winding mountings in the restricted regions of the main gaps in the transformer core tunnels and at the window blocks made available space to redesign the extra coils in the axial field system, using cable and coil construction similar to the original. Only one d.c. supply is now required, thus simplifying the control.

The torus departs from toroidal geometry at the main gaps and window blocks and it is difficult to ensure that the axial field lines are everywhere parallel to the walls. Therefore, when designing the new coils it was decided to aim at a 5 per cent higher field at these places, so that lines of force which penetrate the walls have only a relatively short path length in the plasma.

A complete survey of the new field configuration was made with the torus and redesigned field system assembled in position in the transformer core. Three methods of measurement were adopted. The first was to measure the total flux in the discharge channel in some thirty planes in one quadrant perpendicular to the discharge, using a search coil of approximately the same diameter as the liner ; the results are shown in Fig. 3, the small variations being due to the lumped coil formation of the winding. Secondly, compass plots were taken of the field direction on the horizontal median plane of the torus to give direct evidence that the designed configuration was being achieved. Lastly, the flux distribution in the plane perpendicular to the discharge channel was measured, using a small search coil, with satisfactory agreement between calculated and measured values.

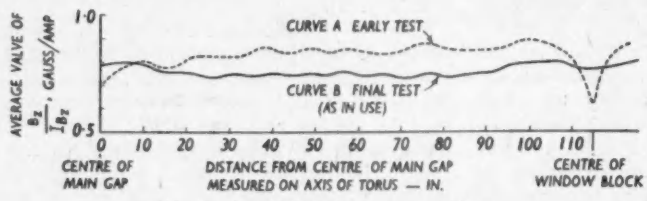
AVERAGE VALVE OF $\frac{B_z}{I_{Bz}}$, GAUSS/AMP
1·0
0·5
CURVE A EARLY TEST
CURVE B FINAL TEST (AS IN USE)
0 10 20 30 40 50 60 70 80 90 100 110
CENTRE OF MAIN GAP
DISTANCE FROM CENTRE OF MAIN GAP MEASURED ON AXIS OF TORUS — IN.
CENTRE OF WINDOW BLOCK

Fig. 3—Axial field plot in n.e. quadrant

Primary Circuit Modification

In " Zeta," experience with ignitrons on clamp circuit duty suggested that they might be sufficiently reliable as series switches to replace the original making switch, i.e. the mechanical switch—saturable reactor combination.[1, 8, 9] The clamp ignitron is required to hold off a reverse voltage of 25kV and the making switch a forward voltage of 25kV, other requirements ($\hat{I}$ > 50kA, conduction time 2–4 milliseconds) being similar for the two duties. The use of ignitrons in place of the switch-reactor combination removes from the firing-control circuit the variables due to the mechanical switch operating time jitter (about 1·5 milliseconds) and the saturable reactor delay of 0·5 to 2·5 milliseconds (depending on applied voltage). Thus, improved synchronisation of the main pulse with diagnostic equipment, oscillographs, &c., is possible. Moreover, the removal of the saturable reactor from the primary circuit reduces the fixed circuit impedance. To secure a further increase in $\hat{I}$ and a reduced current rise time, the " Zeta " primary circuit was examined and other improvements were made as described below.

Ignitron Switching.—Development work by the manufacturer and results of the test programmes at A.E.R.E. showed that BK.178 ignitrons in parallel appeared to meet the requirements for both making and clamping duty. However, the cathode jacket temperature should be between 20 deg.–25 deg. Cent., the lower limit being set by the required peak current and the upper limit by the hold-off voltage. The ignitron anode seals are heated (by means of infrared lamps) to working temperature before the application of voltage, to achieve reliability of voltage hold-off. At currents above about 1kA the arc drop in an ignitron is about 50V, and to ensure satisfactory current balance, resistance is added in series with each ignitron.

The clamp ignitrons have been moved from their former position on the transformer to the point between the capacitor and the making ignitrons. The former position was unsatisfactory, because the clamp ignitrons sometimes ceased conducting early in the pulse and would not reignite, in spite of the use of holding anodes. This was due to the rapid reversals of voltage at the transformer terminals caused by changes of discharge impedance. The voltage at the capacitor is, however, relatively smooth. Moreover, this position has the advantage that clamp current flows in the making ignitrons, biasing them against reverse current due to oscillation between the feeder inductance and the capacitor.[10]

The pulse circuit of " Zeta IA " is shown in Fig. 4. The resistors in series with the clamp ignitrons and the capacitors damp any oscillation if the clamp ignitrons break down in reverse. The damping resistance is divided between the series and clamp paths to reduce losses in normal operation and to limit the reverse voltage on the capacitor during clamping. In spite of satisfactory operation into dummy loads, the making ignitrons were unreliable when working into the main transformer ; after a short period of operation above 15kV, they sometimes failed to deionise during the 0·5 second period between a discharge pulse and the start of condenser charging, thus short-circuiting the charging supply through the transformer primary. Investigation showed that this was due to the long decay of transformer magnetising current in the making and clamping ignitrons. As in " Zeta," the core-bias current was not interrupted during the discharge pulse. The bias current is now reduced from 350A to 10A prior to the main pulse, and the time-constant of the transformer-pulse magnetising-current decay has been reduced from 100–200 to less than 2 milliseconds, because the core flux now reduces to the remanance point. It is reversed subsequently to the opposite remanance point by the bias supply. The reduction of available flux swing (about 10 per cent) is acceptable in the present circuit. With this sequence of circuit operation, the ignitrons carry current for less than 6 milliseconds and operate satisfactorily.

Reduction of Fixed Circuit Impedance.—A non-linear resistor was incorporated in the original " Zeta " circuit to limit voltage reversals.[1, 9] Because the discharge impedance is now known and the clamping operation has proved satisfactory, this non-linear resistor has been removed from the circuit. The effect of this is to increase the voltage applied to the transformer by approximately 4kV, with a proportional increase in peak current.[1]

The leakage inductance of a transformer is principally a function of winding geometry. The original design anticipated a mainly resistive discharge. Consequently, transformer leakage inductance was a secondary consideration, and for mechanical simplicity, the primary winding was placed directly on the ring cores. Since the discharge proved to be inductive[1] the winding has now been positioned as close as possible to the torus, thus reducing the leakage inductance.

The new winding has twenty-four turns, twelve inner turns in insulating tubes carried on the transformer core and twelve outer turns on the torus, short bolted interconnectors completing each outer turn through the core tunnels to allow withdrawal of the torus. Both sets of conductors are spaced evenly about the median plane of the torus and are distributed round the discharge-tube circumference as far as possible. Where not supported on the core in the tunnels, the

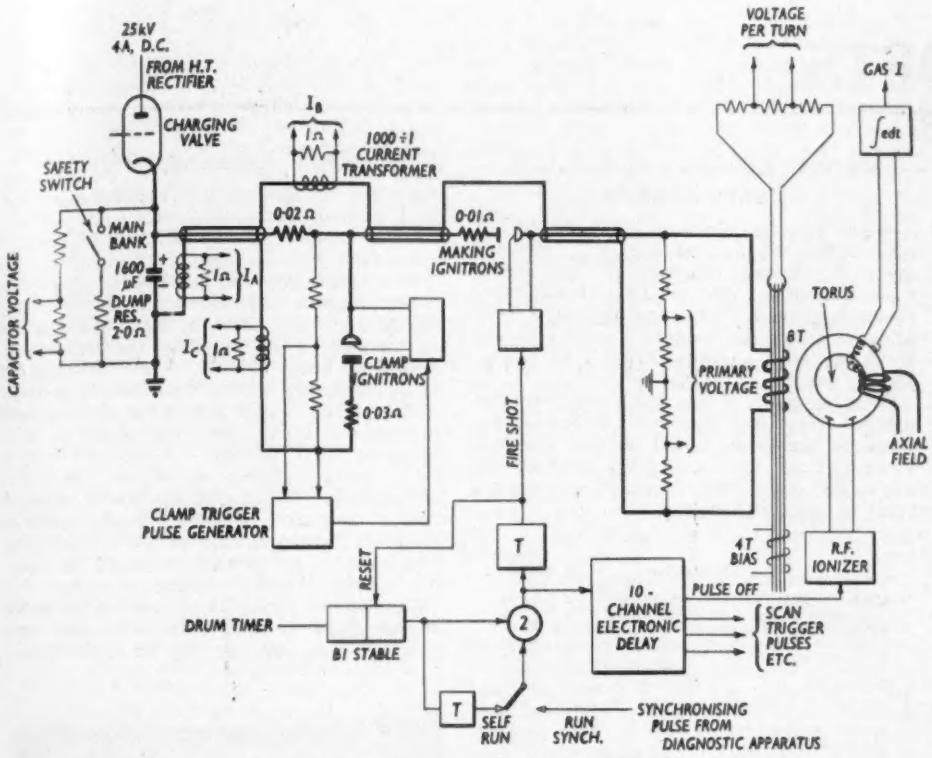

Fig. 4—Main circuit of "Zeta IA"

outer turns are run in glass-fibre tubes clamped with stainless steel bands to wooden saddles over the axial field coils.

The cable remains as previously used, namely 0·1 square inch stranded copper with rubber insulation, and has been arranged for 8 : 1 or 4 : 1 turns ratios, balance being preserved by connecting the top inside conductors to the bottom outside and vice versa.

Sequence Control and Protection.—The main sequence control is provided, as previously, by a drum timer revolving once every twelve seconds to control the charging of the capacitor bank and the necessary auxiliaries. The timer signal opens an electronic gate to pass either a synchronising pulse from a diagnostic experiment or an internally generated pulse in the case of non-synchronised operation, to trigger the time bases of monitoring oscillographs and, after a short time delay, to fire the making ignitrons so initiating the discharge.

The stainless steel liner has simplified the protection system in "Zeta IA." Should the discharge fail to strike, the liner resistance itself is sufficiently low to discharge the capacitor bank without saturating the transformer core, at both turns ratios, the circuit being over-damped under these conditions. Thus, over-swing of the condenser voltage does not occur, and the dump ignitron and its associated trigger and monitoring system have been removed.[1]

Circuit Tests.—Using low voltages on the capacitor bank, the damping in the clamp circuit was checked, and the feeder and transformer leakage inductance were measured. For the latter, the torus main gaps were short-circuited and an additional resistance to give critically damped conditions was inserted in the primary circuit. The fixed circuit inductances in "Zeta" and those of the modified circuit are given in Table II. The modifications have decreased the discharge current rise time from 1·2 to 0·8 milliseconds and increased the peak gas currents from about 200kA to about 280kA with a turns ratio of 8 : 1; the equipment has not yet been used with the 4 : 1 turns ratio.

Using dummy loads to simulate the torus liner resistance, discharge resistance and inductance and the transformer leakage inductance, the complete circuit has been

TABLE II.—*Fixed Circuit Inductances*

	"Zeta I"	"Zeta IA"
Turns ratio	9 : 1	8 : 1
	μH	μH
Feeders and switches	0·21	0·19
Saturable reactor (saturated value)	0·9	—
Transformer primary leakage ...	2·17	1·22
Total external inductance	3·3	1·4

Values given are accurate to 5 per cent and are all referred to the secondary using appropriate turns ratios.

tested under controlled conditions. These results and comparison with calculations based on a simplified circuit have been discussed by Tosswill and Hope.[11]

IMPROVED DIAGNOSTIC FACILITIES

In addition to the original control and monitoring console,[12] a second twin Memotron unit has now been coupled to the eight-channel oscillograph and incorporated in a new "diagnostic console." Selected measurement signals can be routed to the oscillograph via a patch panel, and any two of these signals can be simultaneously monitored on the new Memotron unit for signal level, &c. Instruments are also provided on this desk to indicate important parameters such as capacitor voltage.

To overcome pick-up troubles, all signal leads are now run in screened balanced-twin cables (75 ohms and 300 ohms), the screens being earthed at the eight-channel oscillograph and all oscillographs provided with balanced input amplifiers. Electrical measurements have been improved in detail, particularly the transformer primary voltage, where two potentiometers of the same ratio are now used to reject the significant voltage which appears between earth and the earthy side of the transformer owing to return-circuit inductance (see Fig. 4).

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Obituary

SIR JOHN DALTON, M.I.E.E.

SIR JOHN DALTON, who died in London on May 14 at the age of seventy, was a well-known figure, both in the electrical manufacturing industry and in electricity supply. He was for many years chairman of W. T. Henley's Telegraph Works Company, Ltd., and director and general manager of the County of London Electricity Supply Company and associated companies from 1927 to 1945.

On leaving school he trained as an electrical engineer and on the outbreak of war in 1914 he joined the Royal Engineers (Signals) and served in France, being promoted to the rank of captain in 1917. He was appointed honorary colonel of the Royal Corps of Signals in 1941.

He was called to the Bar at Gray's Inn in 1922 and began to earn a reputation as an authority on the law relating to electricity supply. From 1922 to 1927 he served as legal adviser to the Electricity Commission before joining the County of London Electricity Supply Company. He was also a director of the London Power Company. His published works included *Electricity Act*, 1926, and *Electricity Act*, 1947, and he was the editor of Wills' *Electric Lighting*.

During the 1939–45 war he was regional controller of fuel and power for London and South East England and chairman of the public utilities coal committee. From 1948 to 1953, he was director of the Cable Makers' Association and in 1955 he was president of the British Electrical Power Convention. When he retired from the office of chairman of W. T. Henley's Telegraph Works Company, Ltd., last year, he remained a member of the board of directors. He was knighted in 1942.

TRAFFIC ENGINEERING DIPLOMA.—The Institution of Highway Engineers announces the initiation of an examination for a diploma in traffic engineering, the first session of which will be held in the spring of 1960. The syllabus is in course of preparation and intending candidates are invited to communicate with the secretary of the Institution of Highway Engineers, 47, Victoria Street, London, S.W.1.

AUTOMATIC CONTROL OF HYDROGEN PRODUCTION.—An oil gasification plant, utilising a new, largely automatically controlled process for the large-scale production of hydrogen, has recently been completed by Imperial Chemical Industries, Ltd., at Billingham, Co. Durham, the site erection of the instrumentation and control equipment for the process being carried out by Constructors John Brown, Ltd. The highly instrumented and largely automatically controlled plant is extensively equipped with safety locks, alarms and signals. The main control room, which is air-conditioned, houses two control panels, each 60ft in length, on which are mounted the flow, pressure and temperature instruments, together with the signal lights, safety locks and motor controls. Continuous stream analysis and plant performance monitoring is carried out in three separate instrument rooms equipped with analytical instruments which include infra-red hydrogen sulphide analysers, oxygen analysers and a mass spectrometer for quality control. Many important temperatures are monitored continuously and automatically.

SHORTER REPORTS

Moon as Radio Reflector

IT was announced on May 15 that messages had been transmitted from the Jodrell Bank radio telescope to the United States of America by using the moon as a reflector. The frequency used was 201 Mc/s. Signals were received at the United States Air Force Research Centre, Massachusetts, where the receiving aerial consisted of an 80ft diameter dish. We are informed by Pye Telecommunications, Ltd., maker of the transmitting and receiving equipment used with the Jodrell Bank telescope, that reflection via the moon enables far greater distances to be covered than by using a tropospheric scatter system, which has a maximum range of approximately 200 miles. A link via the moon could cover theoretically half the Earth's surface and could also use a very wide band of frequencies compared with the limited band in which tropospheric scatter working is practicable. Consistency of communication is also likely to be much higher than by systems using reflecting layers in the atmosphere, which are very unstable.

The joint statement on the Jodrell Bank experiments recalled that experiments at Jodrell Bank on the reflection of radio waves from the moon which were made some years ago led to the conclusion that it ought to be possible to use the moon as reflector of radio waves for long distance radio communication. A preliminary demonstration that such reflected signals were in fact intelligible was given by Professor A. C. B. Lovell (Director of Jodrell Bank) during the B.B.C. Reith Lectures last autumn.

The recent experiments have met with the success which was to be expected on the basis of the earlier investigations, and a preliminary lunar link was established during last week. A number of scientific measurements have been carried out using various audio-tones.

Mr. John Brinkley, managing director of Pye Telecommunications, Ltd., has stated that his company has been examining the possibility of communications over great distances of the Earth's surface via the moon because it was felt that present short-wave communications were very unreliable. It was hoped to produce a smaller radio telescope in the future with more power and higher frequency, with a diameter of 25ft instead of Jodrell Bank's 250ft.

Institution of Metallurgists

AT the fifteenth annual general meeting of the Institution of Metallurgists, which was held in London on May 12, Professor A. J. Murphy was elected president in succession to Mr. W. E. Ballard, and delivered a presidential address in which he said that successive councils of the Institution had always realised that, in order to advance the status of the metallurgical profession, adequate standards of admission to the Institution's various grades of membership must be maintained. He went on to discuss the Institution's participation in the work of the Joint Committee for National Certificates in Metallurgy and explained that the committee was now almost ready to publish its revised scheme providing for a higher national diploma as well as a higher national certificate. The Institution's own requirements, Professor Murphy added, would be issued shortly ; if all the hopes were realised, it would become known to the world that the Licentiate or Associate of the Institution was a man whose technology was based on a really sound foundation of science, mathematics and engineering. Metallurgy, Professor Murphy commented, was certainly one of the branches of technology in which advances were liable to be made with disconcerting rapidity and technological knowledge based merely on a grasp of current practice served its owner poorly when he was confronted with an entirely new situation.

At the Institution's annual luncheon subsequently the principal guest was Sir Harold Roxbee Cox, vice-chairman of the National Council for Technological Awards.

Thermal Efficiency of C.E.G.B. Power Stations

A REDUCTION in fuel cost, equivalent to just over £4,500,000, resulted last year from the improved thermal efficiency of the power stations operated by the Central Electricity Generating Board. The overall average thermal efficiency during the twelve months of 1958 was 25·99 per cent as compared with 25·38 per cent for the previous year.

Over one-third of the 84,670 million units supplied from these stations in 1958 was provided by the twenty most efficient stations. These stations had an average efficiency of 30·23 per cent, their individual percentages being as tabulated here.

C.E.G.B. Stations	Thermal efficiency, per cent
Castle Donington (near Derby)	32·91
Ferrybridge B (near Knottingley)	31·20
Drakelow (near Burton-on-Trent)	30·84
Willington A (near Derby)	30·76
Stourport B (H.P.)	30·31
Meaford B (Stone, Staffs)	30·22
Wakefield B	30·12
Stourport B (L.P.)	30·09
Tilbury	30·04
Rogerstone (near Newport)	30·03
Marchwood (near Southampton)	30·02
Stella South (near Newcastle upon Tyne)	29·99
Portishead B (near Bristol)	29·84
Littlebrook B (Dartford)	29·73
Hams Hall C (near Birmingham)	29·52
Plymouth B	29·46
South Denes (Yarmouth)	29·40
Stella North (near Newcastle upon Tyne)	29·30
Dunston B II (near Newcastle upon Tyne)	29·08
Ince (near Ellesmere Port)	28·89

Training in Radiation Dangers

THE United Kingdom Atomic Energy Authority has announced preliminary plans to extend knowledge about radioactivity and to train the specialists needed to deal with radiation hazards.

The problem of national needs in this field has been under consideration since June, 1958, by a committee on training in health and safety, appointed (under the chairmanship of Sir Douglas Veale) by the Authority, following recommendations made by one of Sir Alexander Fleck's committees set up by the Prime Minister after the Windscale accident. Two interim reports have already been given to the Authority by the Veale committee and the final report is expected later this year.

The first interim report recommended special post-graduate courses at universities to train graduates in science or medicine to undertake specialist posts in the field of radiological health and safety. It is expected that two such courses will be available in London University by October, 1959, one run by the Royal Marsden Hospital and the other by the Middlesex and St. Bartholomew's Hospitals, jointly. The possibility of similar courses at Birmingham and Edinburgh Universities and the Royal Technical College, Salford, is also being discussed.

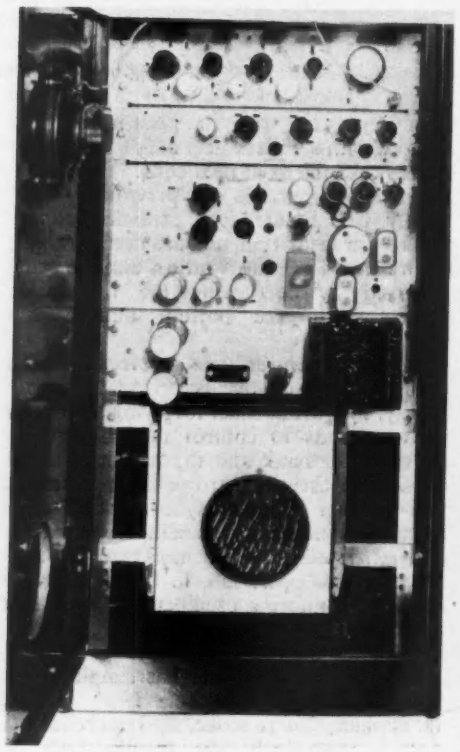
The second report recommended a summer school to be held this year at Oxford for people who, although not engaged on full time health and safety duties, need some knowledge of the problems involved. Accordingly a course will be held at New College in August for candidates sponsored by Government departments or official organisations. It is regarded as a "pilot" scheme; numbers will be limited and it will not be possible to accept individual applications. Those invited are expected to include medical officers of health, local government officers, hospital administrators, some senior civil servants and representatives of industrial managements.

Whether a national training centre is desirable is a question still under consideration by the committee, together with the part to be played, in the training of experts, by the Atomic Energy Authority, universities, colleges of advanced technology and technical colleges.

Telephone Answering Machine

A NEW telephone-answering machine manufactured by Gate Electronics, Ltd., Tudor Grove, London, E.9, provides the user with the facility of recording his own messages, so that, subject to Post Office approval, information additional to identification and instructions to the caller may be given. Normally the duration of incoming messages is set at three minutes, but is variable up to six minutes. The receiving tape has a capacity of three hours, and for convenience in transcribing it also carries the answer tape transmissions which mark the beginning and end of recorded messages. A foot-switch controls starting and stopping of the tape when playing back. Mechanical interlocking between the top tape deck switches prevents incorrect operation. Messages may be played back into headphones or a built-in loudspeaker, or tapes may be removed and played back elsewhere.

The internal apparatus consists of six units interconnected by cableforms with plugs and sockets so that any unit may be removed and replaced without interference with the internal electrical connections. The units comprise the answer loop tape deck, power pack, control unit, monitor, playback amplifier and top tape deck. Thermionic valves are used, except for the silicon zener diode which forms the basis of the monitoring circuits by which the sequence of events is initiated, and provision is made for discriminating between speech and noise, such as dialling tone, which would tend to hold the equipment operative and return an engaged signal after a caller had finished recording his message. Delays of about fifteen seconds are allowed after "please speak now" has been given and during the recording of a message to ensure that the equipment does not shut down during brief pauses. The connection is held by a bias system under the control of the zener diode and no modification is made to the normal telephone and its cradle switch. When a call is received, the bias becomes effective and silences the bell after four rings.

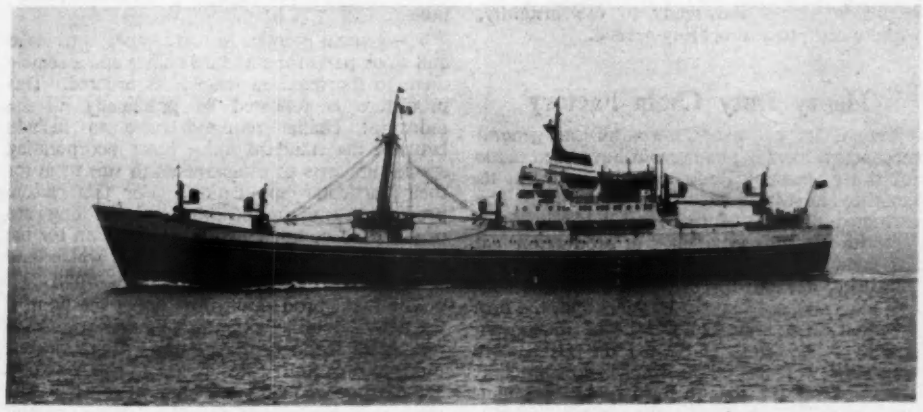


Mounting of independent chassis units in cabinet of telephone answering machine. The "answer" tape is at the bottom and the playback loudspeaker on the cabinet door

Fast Cargo Ship "Bulimba"

THERE sailed recently from London the first of five cargo ships which have been and are being built for the Australia to the Persian Gulf service of the British India Steam Navigation Company, Ltd. This service has been pioneered and fostered by the company, so that from a small beginning in 1947 there are now four 9000-ton "C" class ships on the run, and it is these ships which the new "B" class ships are to replace. The "Bulimba" (illustrated herewith) and her sister ships have been designed specifically for this particular service and incorporate the experience already gained, together with individual requirements as revealed by a detailed trade survey. Basic thinking suggested that to satisfy requirements economically the fleet should consist of several comparatively small ships of moderately high speed so as to provide a flexible and frequent service. The "Bulimba" is the second ship of this name to be owned by the company, the first being a ship of 2503 tons gross which was built in 1881, acquired for the fleet in 1899 and sold in 1922.

The design particulars finally decided upon were: length between perpendiculars 395ft, breadth moulded 59ft, depth moulded to upper deck 32ft 6in, deadweight 7324 tons, gross tonnage 6796, and service speed 16 knots. The order for all five ships was placed with Harland and Wolff, Ltd., to be built and engined at Govan. Exhaustive tests in the Denny Experimental Tank, including performance among waves simulated to cover anticipated sea conditions, were carried out before deciding upon the hull form. The ship as built has a forecastle, combined bridge and poop, and two continuous decks, upper and main, while six bulkheads divide the ship into four cargo holds, motor room and peak tanks, and deep tanks for the carriage of edible oils placed between No. 3 hold and the machinery space.



Fast cargo ship "Bulimba" on trial

Suites are provided for the captain and the owner on the boat deck and for the chief engineer on the bridge deck where the remaining deck and engineer officers are accommodated. In the house on the poop is a smoke room, dining saloon and saloon galley a commodious general office, and laundry together with a number of single cabins for petty officers and their mess. The deck and engine-room crews, mainly in four-berth cabins, and their messes are located on the upper deck. The accommodation is mechanically ventilated and that for the officers, together with the hospital, is air conditioned. Thermotank, Ltd., has manufactured and installed the equipment: the air conditioning unit is supplied with chilled brine from the standby plant for the refrigerator cargo space, and is capable of maintaining 75 deg. Fah. effective temperature when atmospheric conditions are 90 deg. Fah. dry bulb and 86 deg. Fah. wet bulb. The heating and ventilating unit will maintain a temperature of 70 deg. Fah. with the outside temperature below freezing point.

There are three holds forward and one aft of the engine-room: refrigerated compartments are arranged to port and starboard of No. 3 hatch on the second and third decks, and to port and starboard of No. 4 hatch on the second deck, while four deep freeze compartments are placed on the upper deck abreast No. 4 hatch. The total capacity of the holds is about 360,000 cubic feet. Cargo handling has been closely studied and all the weather deck hatchways are fitted with MacGregor push button controlled single pull steel covers. At the tween decks the MacGregor covers are of flush pattern hydraulically operated by remote control from the weather deck. Cargo handling is by both derricks and cranes, and there are five 3-ton ASEA electric cranes which have an operational radius so placed that they cover the whole of No. 1 and No. 4 holds, the forward part of No. 2 hold and the after part of No. 3 hold. The derrick complement, consisting of four 10-ton units operated by four 3-ton a.c. Clarke Chapman electric topping winches, serves the after part of No. 2 and the forward part of No. 3 holds. Clarke Chapman and Co., Ltd., also supplied the electric windlass and the two warping capstans placed aft on the poop.

Freon refrigeration machinery manufactured by J. and E. Hall, Ltd., provides for the refrigerated cargo spaces, deep freeze compartments, domestic chambers and the needs of the air conditioning equipment. The holds are protected against risk of fire. For life saving purposes there are two 31ft fibreglass motor lifeboats each of eighty-five persons capacity and carried under Welin Maclachlan overhead gravity davits.

Electrical requirements are met by four 350kW English Electric turbo-charged diesel-driven alternators generating three-phase 60 c/s current at 440V, arranged two to port and two to starboard, forward in the engine-room. Lighting supplies are single-phase, 230V, 60 c/s fed through two step down transformers; fluorescent lighting is installed in the engine-room and the cargo holds. The cooking and laundry equipment is supplied through a bank of four single-phase transformers, one of which is a standby, at 230V 60 c/s.

Propulsion is by a Harland and Wolff two-stroke, single-acting, opposed piston diesel engine having six cylinders of 620mm bore by 1870mm combined stroke and equipped to burn heavy fuel. The engine is turbo-charged by two Napier MS 500/4 blowers and develops a maximum of 6700 b.h.p.: it drives a four-bladed "Noviston" 16ft diameter propeller at 118 r.p.m. in service. Ample power margins have been provided for weather and hull fouling, so that the designed speed is normally attained on approximately two-thirds power. The cylinders are cooled with distilled water and the pistons with lubricating oil: the air to the blowers is drawn through filter silencers and delivered through coolers to the common air main connected to the scavenge belts. Exhaust gases are led to a silencer-boiler, of Spencer-Bonecourt design, mounted in the funnel, and the low pressure steam from this passes to a double effect Maxim evaporator and distiller which has an output of 25 tons of fresh water per day. Steam at 100 lb per square inch is provided by an oil-fired Clayton boiler when the ship is in port. The consultants to the owners were Messrs. Burness Corlett and Partners, Ltd.

Electrical Installation Equipment

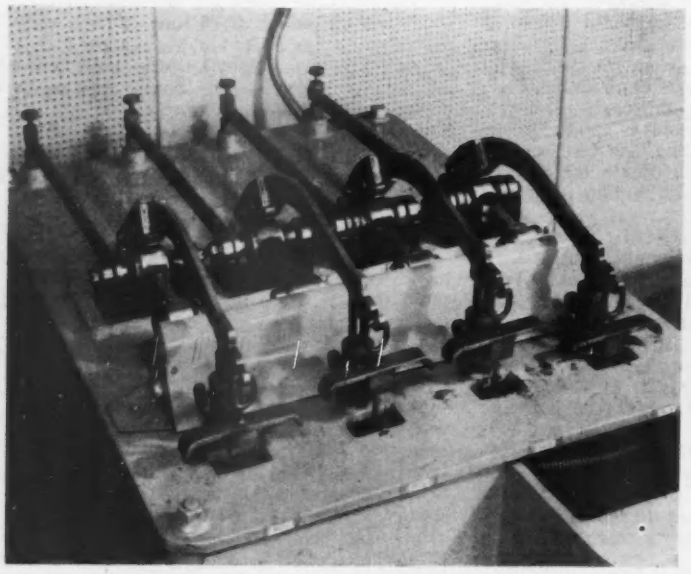
A VARIETY of new electrical installation materials and accessories is now being sold in this country by Siemens-Schuckert (Great Britain), Ltd., Brentford, Middlesex, the sole agent in Great Britain and Northern Ireland for Siemens-Schuckertwerke A.G., Berlin-Erlangen. Siemens-Schuckert (Great Britain), Ltd., is a subsidiary of a holding company which, after the war, purchased the pre-war German-owned undertaking of the same name, and it now holds both manufacturing and selling rights in Siemens-Schuckertwerke products. Recently we inspected examples of the equipment now available, which were shown for the first time on the company's stand at the Factory Equipment Exhibition, Earl's Court. The display concentrated on articles particularly applicable to the requirements of electrical traders and contractors, and of manufacturers interested in incorporating in their own products specialised components which they may not have facilities to manufacture.

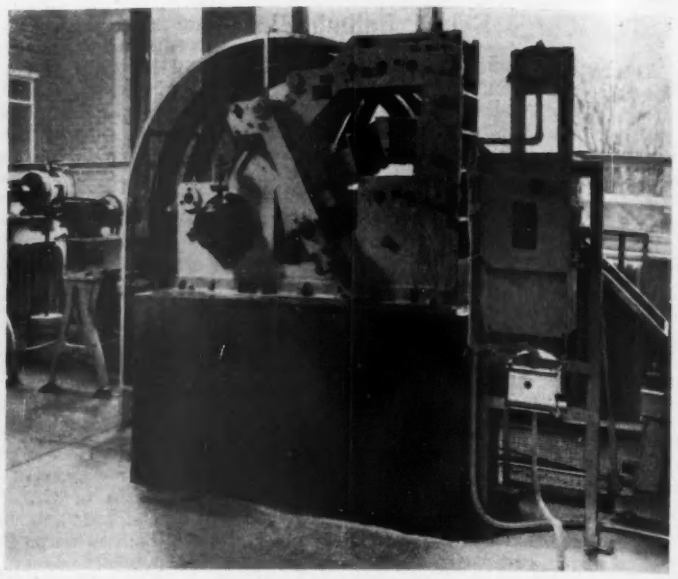
We observed a moulded plastic distribution system suitable for currents up to 200A and designed for use in dust-laden and humid atmospheres, as well as in places where rough usage may be expected. Assemblies of switches and meters are built up by a "wedge" interlocking system between the various units which provides elasticity in the couplings. Components are mounted in the cases by attachment to slotted horizontal bars which are then screwed to fixed vertical mounting bars tapped at close intervals to allow maximum flexibility in fixing. All the switchgear, fusegear and meters are of standard kinds available for incorporation in other forms of distribution system if required, but switches are fitted with plastic operating handles of uniform design.

A new sheet-metal distribution system known as "Stab" distribution boards, is also being marketed. The boards make special provision for the mounting of miniature automatic circuit breakers. A typical circuit breaker in this category is available at present in 6A, 10A and 15A sizes, with 2000A rupturing capacity, but a 25A breaker is in course of production. A thermal trip is provided for normal overloads, and an electromagnetic release for short circuit protection. This unit is one of several which have been developed in order that small electrical installations may take advantage of the improved discrimination and economy in conductor sizes made possible by circuit breaker protection. A range of small contactors was also shown, of dimensions and ratings particularly applicable to floor-heating installations. In the heating field, also, the company is marketing a 1kW infra-red heater for overhead suspension by chain or brackets. Heaters can be suspended in continuous rows by replacing the normal end covers with connecting covers.

Kingston By-Pass Modernisation Proposals

THE MINISTER OF TRANSPORT AND CIVIL AVIATION has announced that he has asked Surrey County Council, whose chief engineer is Mr. D. S. Samuel, to complete plans for modernising Kingston by-pass with a view to starting work before the end of the present financial year. Kingston by-pass, which was opened in 1927, is one of the principal radial routes from south-west London. Although its usefulness has been seriously impaired by pre-war ribbon development, the Ministry estimates that its improvement would be less costly than building an entirely new road. The Minister now proposes to complete the construction of dual carriageways throughout the whole length of the by-pass, at an estimated cost of £1,700,000.





(Left) Four bushes being subjected to differing radial loads (imposed by the second order levers through the rollers), differing torsional loads (applied by the arms at the far side) and two different amplitudes (generated at the grease-lubricated bearings on the pivoted arms). (Right) A constant-amplitude fatigue test machine to accept suspension units for road and rail vehicles

Rubber-Bonded-to-Metal Laboratory

LAST week there was opened the new headquarters of Metalastik, Ltd., in Leicester. The new building, for which the architects were Pick, Everard, Keay and Gimson, and the contractors J. Chapman and Sons, Ltd., houses the research department laboratories, equipped to carry out tests both on standard test pieces and on actual production components. We illustrate here two of the machines designed and built by the firm to carry out fatigue tests on components, in the one case small bushes such as might be used on vehicle suspensions or vibratory conveyors and in the other a large rubber spring for the bolsters of London Transport underground trains : the large machine runs at between 80 and 160 r.p.m. A particularly important class of test when control of vibration is sought is the measurement of dynamic stiffness and damping : there was demonstrated on the occasion of our visit equipment to impose oscillating loads between ounces and tons on rubber test pieces or suspension units, the amplitude of a known mass being plotted on a base of frequency. Many of the test rigs can test components at controlled temperatures, and bearings of silicone rubber were seen under test at 100 deg. Cent.

A further aspect of the work of the research department is the need to measure vibration and shocks in order to counteract them and show that they have been counteracted. Among the various electrical and mechanical instruments on show we were impressed by an outstandingly compact S.I.F.M. accelerometer pack which produced a photographic record of the accelerations of a vehicle along three mutually perpendicular axes : an additional channel can record angular acceleration or velocity, in order to allow true motion to be deduced from the accelerometer traces. An alternative system of recording with high impedance and high frequency response employs ultra-violet light reflected on to sensitised paper : in this case the record is visible and ready to use instantly, without any processing being needed.

Heavy Duty Chain Factory

CHAINS for conveyors, elevators and general mechanical handling equipment have been made for thirty years by Renold Chains, Ltd., at its factories in Manchester and Coventry. The restricted amount of space available in these factories for this special class of production had for some time made it difficult to meet the increasing demand for heavy mechanical handling chains when, some three years ago, the firm acquired an existing factory site at Burton-on-Trent. A new factory erected on this 5½-acre site, which was recently opened, has been specially equipped for the manufacture of heavy chains at a cost of about £1,000,000. When full production is attained in the near future, nearly 3000 tons of chains will be made a year in this factory and 600 people will be employed.

The chains made by this firm in the standard ranges cover conveyor and elevator hollow-bearing pin chains of 6000 lb and 12,000 lb breaking load, and solid bearing pin chains of 3000 lb, 7500 lb and 15,000 lb breaking load. A further standard range of chains, attachments and wheels are available for 24,000 lb, 30,000 lb, 36,000 lb, 45,000 lb, 60,000 lb and 85,000 lb breaking loads. In addition very heavy duty chains can be made for from 100,000 lb to 300,000 lb breaking loads, as well as a variety of chains of special design for industrial applications.

Raw materials store, with press bay in the background

The general practice in this factory is to make and stock parts for standard chains and assemble them to the required lengths as ordered. This procedure is followed as practically all the industrial chains required have to include between the standard links, links incorporating special brackets or attachments to suit them for their particular application. For this reason, production is organised to provide for long runs of standard components, with provision for the speedy manufacture of special parts which have to be incorporated in the chains on assembly.

The main production flow down the floor of the new factory is from a large material stores at one end, through the component fabricating lines, to a central stores area. In this stores the standard components are batched together with the special fittings and passed on to the assembly sections at the lower end of the shop. Parts such as pins, spindles and bushes made from bar stock are turned in a section equipped with automatics and capstans on one side of the shop. The method of transferring work from this section to an inspection area is of interest. A continuously-driven haulage chain system set in a trough below floor level passes right round the machine lines. Trucks coupled to this chain at intervals are built to carry work trays into which the machine operators load the components in specified batches. The trucks carry the trays to a central point where the trays automatically skid off on to the conveyor system of a cleaning and drying plant. From this plant the trays gravitate down a roller conveyor line to inspection benches. Other sections of the factory are served by an overhead conveying system.

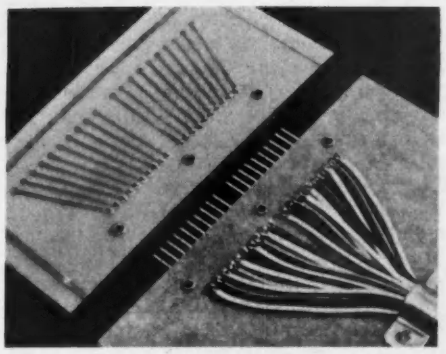
The links of flat plate are either punched or cropped on lines of presses in the case of long runs of standard parts, or flame-cut on a multi-head machine when small numbers or heavy gauge plate are involved. The head of the press section can be seen in the accompanying illustration. Some of these machines are connected by conveyors for multi-operation working and others are served by induction heating plants. Parts for special brackets or other fittings required are also made in this section and assembled on resistance welding machines.

Chain assembly is carried out on lines of presses and riveting machines equipped with special tooling for progressively assembling the components into links, and connecting the links

together with the required brackets or other fittings interposed at the specified intervals. From inspection benches at the end of the assembly lines the completed chains are suspended on an overhead conveyor system and carried through a lubricant impregnating installation adjoining the despatch area. At present components requiring heat treatment have to be taken to one of the firm's other works, but a large automatic gas carburising plant is to be installed in the new factory in the near future.

Printed Circuit Connectors

To facilitate the interconnection of printed circuit units, Siemens Edison Swan, Ltd., 155, Charing Cross Road, London, W.C.2, has recently placed on the market a range of miniature multipoint connectors. These are made in units of ten pins and sockets, each only 1in in length overall. At the outset the units have been manufactured in nylon, but P.T.F.E. insulation, to be introduced at a later stage, will allow for working temperatures between the extremes of

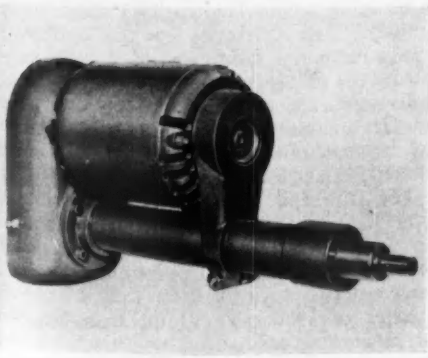


Multi-way connections on printed circuit chassis

−50 deg. and 200 deg. Cent. The accompanying illustration shows two ten-way units mounted side by side. In each unit the spacing between pins is 0·1in, as is common in printed circuit work, while the spacing between the adjacent end pins of two units is 0·2in. This 0·1 module is maintained for assemblies of up to sixty units and assists the planning of multi-way connections where strict space limits have to be observed. The connectors are available in forms other than that illustrated for general use in electronic equipment with wired as well as printed circuits, including rack assemblies.

Electro-Mechanical Thrust Units

A STANDARD range of self-contained electro-mechanical thrust units introduced by George Angus and Co., Ltd., Hebburn-on-Tyne, is available in various sizes. These units are designed to provide alternatives to solenoids and hydraulic, compressed-air and vacuum-operated cylinders, and they can be operated directly from standard a.c. electrical supplies, using standard switch gear. Each unit incorporates an electric motor, totally-enclosed



Electro-mechanical thrust unit in which a standard a.c. motor actuates a ram through gearing

reduction gearing, and a ram which is extended or retracted by a screwed shaft and nut arrangement. A limit switch device normally fitted to control the stroke can readily be adjusted to give any stroke length within the range of the unit.

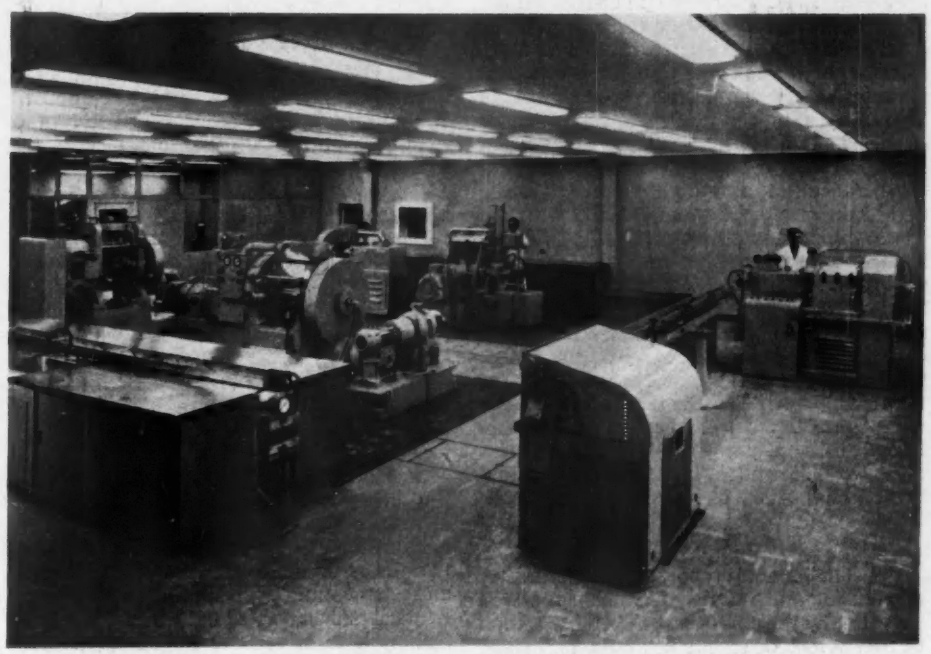
The "Autoram" units, as they are known, are available in sizes suitable for thrust loads from 0 to 5000 lb with maximum stroke lengths to suit users' requirements. They are made for foot-, flange-, or trunnion-mounting, and a typical design can be seen in the photograph we reproduce.

Elastomers Research Laboratory

SINCE it was first commercially produced in 1932 the production of neoprene has steadily expanded to meet the demands for synthetic rubbers. For many years E. I. Du Pont de Nemours and Co. has been exporting neoprene to this country and the Continent, and, as the market, especially in the post-war years, has expanded with increasing applications made possible by the particular qualities of the material, consideration was given to siting manufacturing capacity closer to existing and potential markets. Eventually in 1956 Du Pont Company (United Kingdom), Ltd., was formed, and to further the decision to build a full-scale neoprene synthetic rubber plant, the first by the company outside the United States, a 380-acre site was acquired near Londonderry, Northern Ireland. To provide a technical service to customers and the new plant, and also to develop new uses for neoprene, it was decided last year to construct an elastomers laboratory at Hemel Hempstead: last week we were able to make a tour of this facility which has been completed recently. The laboratory is located on the industrial estate at Hemel Hempstead and occupies an area of about 5¼ acres of which less than one-third has been developed.

The prime function of the laboratory is to solve problems concerning the application of rubber products to a large range of industries including: building, engineering, motor, cable manufacture, railways, paint manufacture, shipbuilding, aircraft construction and mining. The modern instruments and testing devices installed are able accurately to duplicate the majority of the processes employed by rubber manufacturers and to simulate working conditions so that suitable formulations can be arrived at for any specified product and operational circumstances.

There are three principal operational areas in the laboratory, namely; dry processing, fluid processing and physical testing. In the dry processing department, of which we include a view, the equipment deals with compounding and processing problems related to the manufacture of moulded products, calendered sheet, extrusions, wire and cable. Of particular interest is the high-pressure vulcanising unit which simulates the continuous vulcanising conditions in the wire and cable industry. It consists of a steam chamber set over a water chamber; lengths of wire covered with synthetic rubber are placed in the steam chamber and vulcanised by steams at pressures ranging from 100 lb to 275 lb per square inch, and then lowered into the water chamber at the same pressure. In the fluid processing area is an ultrasonic homogeniser, a high-speed ball mill and other machines such as are used by latex goods fabricators and paint manufacturers, &c. The extensive physical testing section is equipped for establishing dielectric strength, for measuring insulation resistance, resilience and hardness, and also resistance to abrasion and to cracking under repeated bending. Special electronic testing equipment which operates from −70 deg. to 550 deg. Fah. enables the physical properties of rubber samples to be determined, from tensile strength to tear resistance and adhesive strength, while a "weatherometer" simulates conditions ranging from intermittent rain and high humidity to dry and humid sunshine. Other equipment is designed for accelerated ageing tests, and to establish behaviour of the synthetic rubbers in varying concentrations of ozone, while a salt spray cabinet is associated with problems relating to the use of maintenance coatings of neoprene and "Hypalon" synthetic rubber for the shipping industry.



Part of the dry processing department of the Du Pont elastomers research laboratory

Foundry Trades Exhibition

NEARLY a hundred firms are represented at the Foundry Trades Exhibition opened at Bingley Hall, Birmingham, by Sir Frederick Scopes on Thursday last, May 21. This exhibition, the first of its kind to be organised exclusively for the foundry industry and allied trades, will be open daily until May 30.

The exhibits include a wide selection of the plant, materials and equipment used in ferrous and non-ferrous foundries, die-casting shops, &c. Much of the plant is shown in operation and some interesting demonstrations have been arranged by a number of the exhibitors. A complete miniature foundry manned by students from the National Foundry Craft Training Centre demonstrates the class of work and training carried out.

Industrial and Labour Notes

Development Areas

On Thursday of last week, the House of Commons debated Government policy for the Development Areas. The matter was raised by an opposition motion which called upon the Government to use far more vigorously the powers under the Distribution of Industry Acts to bring new industry and employment to the development areas ; to restrain excessive development in congested areas, and to schedule as development areas additional districts where high unemployment existed.

The principal spokesman for the Government was Mr. John Rodgers, Parliamentary Secretary to the Board of Trade. He pointed out that in the last few months the Government had taken a great many steps to "reflate" the economy in an attempt to create a general background of further employment which should make the steering of industry easier than it had been in the past. His experience, since he had been at the Board of Trade, had shown that at a time when there were fewer industries on the move it was more difficult to steer them to development areas. Therefore, Mr. Rodgers asserted, it was essential that the location of industry policy should be pursued just as vigorously, if not more vigorously, in times of industrial expansion than in times when unemployment figures were high. The long-term difficulties of the development areas, Mr. Rodgers emphasised, would not be solved except by a policy of steering industry. That was much easier when industry was expanding and when there were parts of firms which could be hived off or whole industries which could be steered into the development areas. But, Mr. Rodgers added, he was convinced that one of the reasons for the unemployment in the development areas was the technological changes which were bound to happen and would go on happening. No Government could seek to frustrate those technological changes.

Factories in the New Towns

The annual report of the Ministry of Housing and Local Government for 1958 says that by the end of last December a total of over 9,700,000 square feet of factory space had been completed in the "London new towns," either by the development corporations or by industrialists on land leased to them by the corporations. These factories, it is stated, give employment to over 42,700 workpeople and are expected ultimately to employ over 52,000. At the end of the year, just over 2,000,000 square feet of factory space, expected to give employment to over 7000 workpeople, were under construction. Most of the towns have a reasonable variety of industry, although the engineering industry represents nearly 60 per cent of the total.

The report adds that any estimate at this stage of the amount of additional factory space needed by the time the corporations stop building, in order to provide employment for new migrants and school leavers, must be speculative. It is thought, however, to be of the order of 5,000,000 to 7,000,000 square feet over what is already under construction, most of which will be required in Basildon, Harlow and Stevenage.

Employment

The Ministry of Labour has stated that, at the end of March, the number of people in civil employment in Great Britain was 22,798,000 (15,138,000 men and 7,660,000 women). This was 1000 more than at the end of the preceding month.

An analysis of the figures shows that the biggest change during March was mainly a seasonal one in the building and contracting industries, where the labour force increased by 21,000 to a total of 1,470,000. In "professional, financial and miscellaneous services" the number of people employed increased by 8000, but in the basic industries of agriculture and mining there were decreases in the labour forces of 7000 and 3000 respectively. In the manufacturing industries, there was an overall drop of 12,000 during March, making the total employed in those industries 9,044,000, compared with 9,236,000 a year earlier. In the vehicle building group, there was an addition to the labour force of 4000, making a total at the end of March of 1,233,000, but in the "engineering, metal goods and precision instruments" group, employment declined by 9000, giving a total of 2,780,000, compared with 2,837,000 at the end of March, 1958.

Proposed Lecture Theatre

The carrying out of the Hyde Park Corner reconstruction scheme has afforded an opportunity for the construction of a lecture theatre at the headquarters of the Royal Aeronautical Society, backing on to the new Apsley carriageway. The Society at present has no lecture theatre or back entrance, and were it not for the reconstruction scheme the erection of a hall behind the building at 4, Hamilton Place would be prohibitively expensive. The theatre designed by Ley Colbeck and Partners would seat approximately 325 ; the planning permissions necessary to build it have been secured, and the land required can be leased until 2004. If it is to be built it must be commenced in September this year, and the council of the Society expects the cost of the project to be £150,000. The subscription income of the Society being £40,000 per annum, the Council is seeking to raise two-thirds of the total without the Society, and is presenting an appeal to the aeronautical and associated industries. While the Society is eager to have contributions made over seven years under deed of covenant, since income tax paid on such sums should be recoverable, it is necessary for the Society swiftly to secure firm commitments rather than the qualified promises obtained to date, because of the short life of the opportunity to build.

British Railways Workshops

Early in 1956, the British Transport Commission announced its policy for the future of British Railways workshops, and said that the shops would, with minor exceptions, be fully employed for the succeeding five years. The Commission has recently given careful consideration to the whole matter with the aim of establishing policy for the future. Its conclusion is that the statement of principles made in 1956 still holds good and that there is no reason to depart from the general points of that policy. But since that time various factors, some of them outside the Commission's control, have necessitated an acceleration of the modernisation plan and a consequential acceleration in the process of shaping workshops policy to meet the requirements of the future.

In formulating its future policy, the Commission says it has felt bound to give over-riding consideration to the interests of the railway industry itself ; to have regard to the future of its own employees ; to seek the maximum economy and efficiency in manufacture and repair and to ensure close co-operation with industry so that the maximum benefit may be obtained from its experience, resource and enterprise. The Commission's policy for the future will be to continue to use its own workshops for the manufacture of equipment and components for which the shops are laid out, as well as for the repair of all equipment. This is on the proviso that costs are competitive. The Commission will continue to rely on outside industry for the supply of new diesel and electric power equipment and may purchase complete locomotives and rolling stock from industry as the programmes require and when circumstances justify such a course.

The Commission points out that the introduction of modern kinds of motive power and equipment must lead to a reduction in the existing fleet of steam locomotives and rolling stock. The reductions in workshop capacity of British Railways resulting from the implementation of this policy will be carried out by phases, of which only the initial phases can be decided at this time. There will also be a reduction in the orders placed on outside industry, especially for wagon repair. The trade unions concerned have been informed of these developments in the Commission's policy.

Iron and Steel

The Iron and Steel Board says that steel production is improving. The output of ingots and castings in April averaged 387,300 tons a week and the steel furnaces operated to 81·5 per cent capacity, compared with 76·5 per cent during March. Pig iron production in April was at the rate of 231,000 tons a week, compared with 221,000 tons in March. The Board points out that figures are not yet available to show how far the increase in steel output in April was due to a rise in consumption or to a decline in the rate of stock reduction, or to both.

What is clear is that the increase in steel production in the first quarter of this year, compared with the fourth quarter of 1958, was due primarily to a lower rate of reduction of consumers' stocks. Steel deliveries to home users during the first quarter of this year were about 8 per cent higher than in the final quarter of last year. Nevertheless, they were still about 17 per cent below the high rate of delivery reached in the first quarter of 1958. Some improvement has taken place in steel deliveries to the publicly-owned and investment goods industries, other than railways, and deliveries to the consumer goods industries continued at a high level during the first quarter of this year. Recent indications are that demand for sheet and tinplate continues to be strong ; it is improving for most of the lighter steel products and to some extent for heavy sections.

The Iron and Steel Board and the Joint Iron Council have announced production figures for iron castings in the first quarter of this year. The total output was 828,100 tons, compared with 814,900 tons in the last quarter of 1958. The Joint Iron Council says that, after easing slightly in the third and fourth quarters last year, castings output in the automobile section established a new all-time record in the first quarter of 1959.

German Industries Fair, Hanover

No. IV—(*Concluded from page 784, May 15*)

With a hall space totalling 270,000 square metres, and an open area of 140,000 square metres, the German Industries Fair was held at Hanover during the period April 26 to May 5. From small beginnings in 1947, it has developed into the most important technical fair on the European Continent. Although the rate of its physical expansion is now levelling off, its commercial importance is still increasing, as indicated by the growing foreign participation, which rose from 14 per cent in 1958 to nearly 17 per cent this year.

Siemens

MUCH attention was aroused by the "Model 2002" digital computer, shown on the main display stand of Siemens and Halske Aktiengesellschaft and Siemens-Schuckertwerke Aktiengesellschaft, Berlin/Siemensstadt-Munich-Erlangen. Designed to deal with a large variety of arithmetical work, in particular commercial and administrative tasks, the "2002" (Fig. 24) is a fully transistorised machine with average calculating speed of 2000 operations per second. It uses the decimal system, representing each decimal figure by a binary tetrode; a "word" consists of twelve decimal figures and a sign, and can be interpreted as either a number, word or operation. From a punched tape or punched card input unit, the data are transferred to a rotating drum store (access time 10 milliseconds), from which information is transferred to a 100,000 word quick access magnetic core store which has an access time of only 5 microseconds. Calculations are carried out by the arithmetical unit in conjunction with the fast access store, and the result is issued to an output unit which may be a punched tape or punched card machine, teleprinter, tabulator, or analogue indicator. In the exhibition demonstration, for instance, the successive positions of a series of balls bouncing inside a box and finally escaping through a hole in the bottom were continually calculated for varying initial conditions, and shown in rapid succession on a cathode-ray tube, thereby giving the impression of the actual path being traced.

Fig. 24—Model "2002" transistorised digital computer. A teleprinter (foreground) serves as input and output unit. The control desk is on the right; on left (background) are the cabinets for the arithmetical units and memory stores—Siemens

The approximately 2500 arithmetical units of a medium-size "2002" computer are largely standardised and take the form shown in Fig. 25, of approximately postcard-size plug-in panels, with printed circuits and dip-soldered components.

The "Selex" system for the internal distribution and handling of information within an organisation permits the splitting-up of information of a recurring kind (e.g. incoming orders) into components of interest to the various departments, such as sales, stores, dispatch, &c. Each component message is typed out in the most appropriate manner by teleprinter, or recorded by punched tape or card machines. It is only necessary to write out the complete message once on the appropriate form. A prearranged punched-tape controlled programme then apportions the various sections to the appropriate recipients and also controls the layout of the transmitted items. Besides using a teleprinter, one can feed in information by means of the new "LSK" punched card with combined information and programme punching. Prepared on a special machine, this card also shows the clear text above the punched holes; it is particularly useful for repeat information.

A demonstration rig showed a speed control for a 20kW motor, employing "VE31" grid-controlled single-anode rectifiers in conjunction with transistorised grid circuits. This rectifier has a current capacity of 30A and can be combined into units to handle up to 220kW, a range previously reserved for the Ward-Leonard converter. Its small size—it is only 350mm high and weighs 5 kg—makes it possible to place the speed control unit next to the motor. The quick response of this kind of speed control was made evident by letting the motor drive a small siren and varying the pitch by playing on a two-octave keyboard, producing an organ-like effect.

Increasing application of cast resins has led to important advances in the design of high tension insulators. In Fig. 26 a comparison is made between porcelain and cast resin insulators for 110kV. The resins are used either pure or mixed with quartz powder, and are stated to remain stable at least up to the temperatures which the bonding of porcelain insulators can withstand. Cast resin insulators are very resistant to impact, and since a smaller radius can be formed at the edge, they are less affected by dirt. Savings in size can be made in many instances; for instance, condensers can be built which require no separate outer casing.

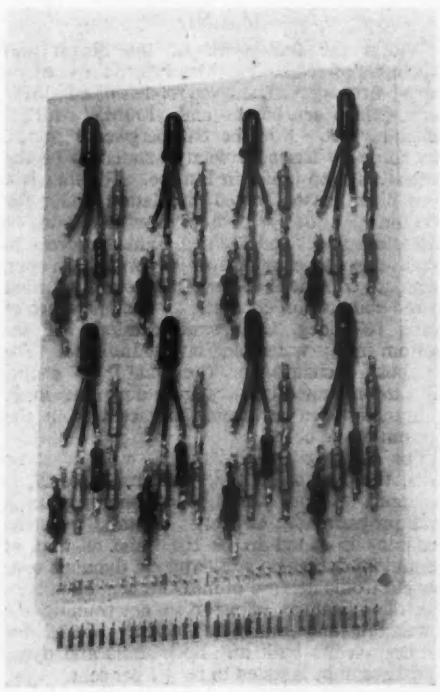


Fig. 25—Circuit panel units for model "2002" digital computer—Siemens

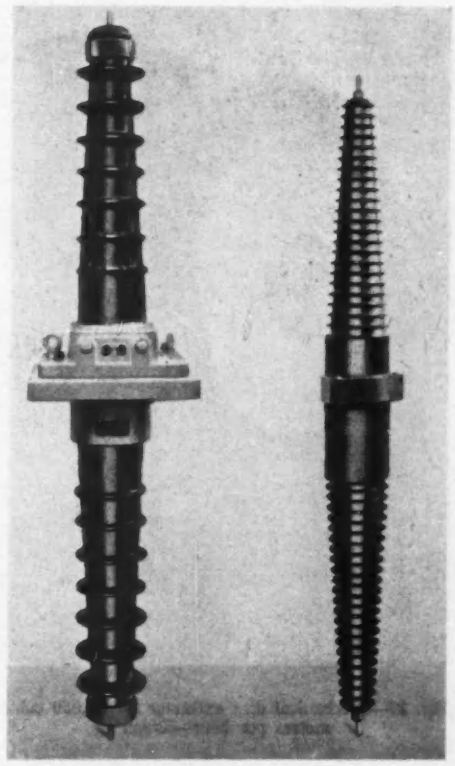


Fig. 26—110kV insulators of (left) porcelain (right) cast resin—Siemens

The facsimile telecopying equipment "Hellfax" has been fitted with automatic paper feed so that the receiver can now operate without attention. A Hall generator, which is only 2mm wide and 0·3mm thick, permits magnetic measurements to be carried out in very narrow gaps. The "Oscillomink" is an oscillograph for frequencies of up to 1000 c/s which records on paper by means of a fine jet of ink.

Fried. Krupp

The centre of attention at the stand of Fried. Krupp, Essen, was the BBC/Krupp high-temperature reactor to which we have already referred (page 781 *ante*). Elsewhere on its 5000 square metres display area, the Krupp concern presented an impressive cross section of recent achievements, ranging from a double track-laying support, weighing 102 tons, as used on a 5000 cubic metres per hour rotary excavator, to light-weight compressors for driving railway tamping tools. Another main exhibit was a mobile crane built by Krupp-Ardelt G.m.b.H., Wilhelmshaven, equipped with a 65m long boom. The same company showed two versions of a novel design of dust extractor which, it is stated, has been applied with particular success to the filtering of converter smoke. Our illustration, Fig. 27, shows the larger unit, for 15,000 cubic metres per hour; it is a combination of a rotary brush and a radial extraction fan. An important section of the exhibition was devoted to the fabrication of titanium into larger components, exemplified by equipment for a chemical plant, having a combined weight of several tons. These included part of a fractionating column of 2m diameter and 2m length. Among other exhibits we noted a large nut for the column of a hydraulic press, made from a spheroidal graphite casting and weighing 8 tons. A diesel-hydraulic ore carrier for the Renn plant "Rhein-Ruhr 2," for standard railway gauge, measures 16·24m over buffers and weighs 50·7 tons. It can carry 35 cubic metres of material, weighing up to 80 tons. Equipped for pneumatically operated

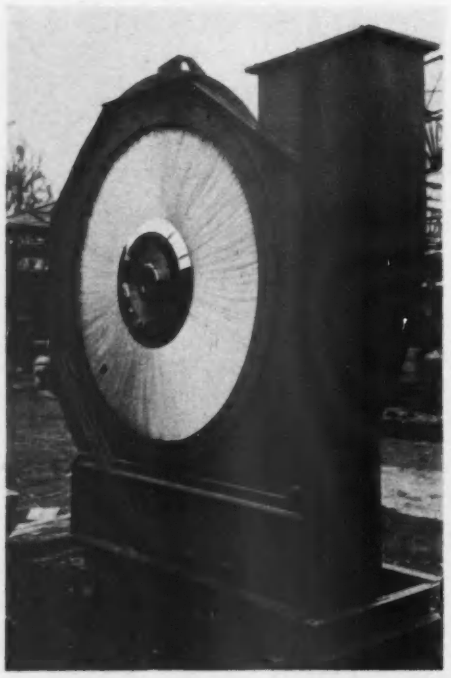


Fig. 27—Mechanical dust extractor for 15,000 cubic metres per hour—Krupp

side discharge, the bunkers are protected against corrosion and wear by "Moellerit," a plastic coating in which small glass beads are embedded by blasting while it is still soft. Progress made with vacuum casting by Bochumer Verein für Gusstahlfabrikation A.G. was illustrated by a 29-ton turbine shaft 5·28m long and having a maximum diameter of 1·626m.

Orenstein-Koppel und Lübecker Maschinenbau A.G.

Several new developments were also to be seen on the open-air stand of Orenstein-Koppel und Lübecker Maschinenbau Aktiengesellschaft, Dortmund. A universal track-laying excavator, the "LO72" was shown equipped with 0·3 cubic metre backacter shovel; the machine has a service weight of 8·45 tons and is fitted with a 36 h.p. diesel engine. A similar smaller machine is the "LO41" with a 0·25 cubic metre shovel and 28 h.p. engine, weighing 5·8 tons. A pneumatic-tyred excavator, the "LSO41" can move on roads at up to 15km per hour and can be used with various excavating tools, including shovels ranging from 0·23 to 0·3 cubic metre and grabs up to 0·5 cubic metre, or as a crane for lifting up to 2 tons. The maximum thrust at the bucket teeth is 5·2 tons, and the weight of the machine 5·9 tons. The "AS150" hopper truck is a larger version of the "AS100" and is designed to carry 1·2–1·5 cubic metres or up to 2200 kg. An air-cooled, single-cylinder, two-stroke 16 h.p. diesel engine and four-speed and reverse gearbox give speeds up to 16km per hour forwards and 5·1km per hour reverse. A power take-off can be fitted. The 105 h.p., 29km per hour "EH580" grader is equipped with bulldozer front blade and central grader blade, the latter being rotatable about the longitudinal axis of the machine and at right angles to this axis; the blade can thus be tilted on either side up to the vertical position. The machine is hydraulically operated and fitted with "ZF" power steering. An air compressor enables the tyre pressure to be adjusted at any time to requirements. The scarifier has nine tines and a working width of 1300mm. The grader weighs about 12·2 tons.

A rotary excavator-loader, design Rosetz, is a track-laying machine of up to 150 cubic metres per hour capacity, capable of taking up tipped material up to 500mm size and excavating virgin soil with rock inclusions. The cutter has a toothed rim supported on a toothed spider; it has a diameter of 1·8m and can be tilted about a horizontal axis to vary the cutting angle. Mounted at the end of a hydraulically adjustable boom, the cutter can operate at any height between +3·6m and −0·5m. Material scraped up by the cutter which is mounted on a U-shaped shovel blade, is transferred by a plate conveyor to the machine and from there to a 12m long band conveyor which can be slewed through 180 deg. The drive is either electric, diesel-electric or, for underground use, pneumatic. Installed capacity is 30kW.

Focke-Wulf G.m.b.H.

The hydraulic jack lift shown by Focke-Wulf G.m.b.H., Bremen-Airport, Hünefeldstrasse 1-5, (Fig. 28) is designed to serve as lifting as well as conveying equipment. Besides its use in warehouses, the trolley can be used in machine and press shops for setting up heavy press tools, &c., as our illustration indicates. With a tare weight of less than 100 kg, the trolley can carry a load of 250 kg; height of lift is 1350mm.

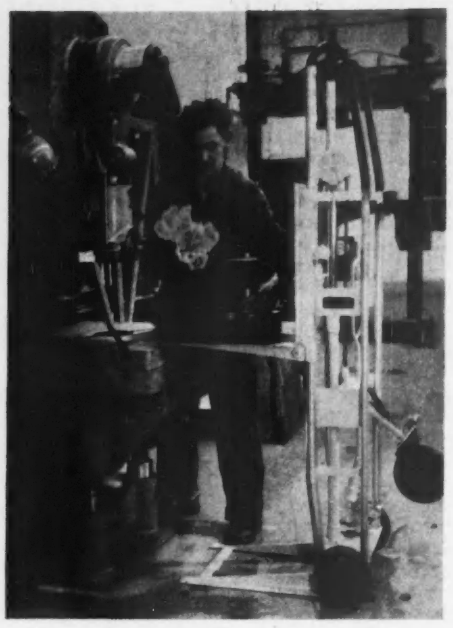


Fig. 28—Hydraulic lifting trolley for lifting and transporting items up to 250 kg—Focke-Wulf

M.A.N.

Within the framework of the Steam and Nuclear Power Section, Maschinenfabrik Augsburg-Nürnberg A.G. showed models of a 100MW turbo-generator block and 150MW turbo-generator set. For the Saarbergwerke mines, the company has built what is stated to be the largest slag tap boiler in Europe. The unit is a 29m high Benson forced circulation boiler for 450 tons per hour, with stop valve conditions of 210 atmospheres and 530 deg. Cent. In order to achieve an efficiency of over 90 per cent, in spite of an ash content of 35 per cent, the ash is melted in the combustion chamber, at a temperature of some 1600 deg. Cent., and extracted at the bottom into a water tank and granulated. The combustion chamber has the usual "U" shape, with top-mounted burners firing down one limb, and the molten ash being extracted from the bottom of the bend.

For carrying out dynamic as well as static tests, the 100-ton testing machine, Fig. 29, is equipped with pulsator and electronic measuring and programming devices. In static tests the accuracy is stated to be the same as that of pendulum dynamometers, while in dynamic tests the electronic method of measurement eliminates the main sources of error in determining the maximum and minimum loads. Means for calibration are built in. Both static and dynamical accuracy is stated to be ±1 per cent.

The model "AV25/2" mobile crane has a capacity of 20 tons at 3·5m radius (full circle of jacks are lowered) or 16 tons at 4m (full circle slewing without jacks). A reinforced version can slew 25 tons at 3m radius with jacks applied. For use in building construction, a 31m long main boom with 9m long extension jib can be employed.

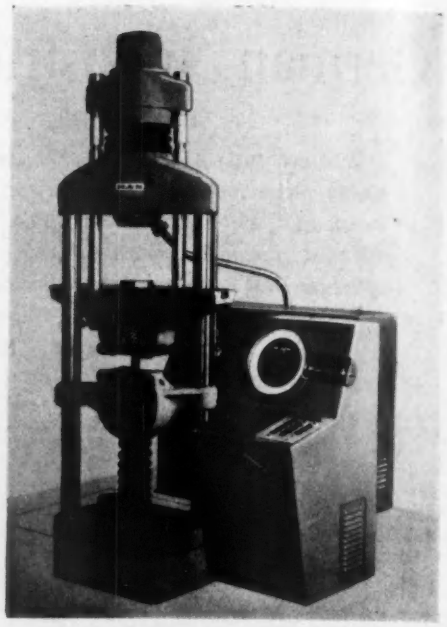


Fig. 29—100-ton universal testing machine with pulsator and electronic equipment for measuring static and dynamic loads—M.A.N.

Trumpf and Co.

An addition to its range of universal shears and nibbling machines is being shown by Trumpf and Co., Stuttgart-Weilimdorf, Josenhansstrasse 11. The copying and co-ordinate nibbling machines, model "CN63" or "CN80" (Fig. 30), make it possible to cut sheet metal components without any marking-off, using templates of any shape. The sheet from which the workpieces are cut does not have to be manipulated or turned in any way. One or more of the first items to be cut out can be employed as additional templates, so as to enable the cutting to be carried out with a minimum waste of material. The same machine can cut out rectangular openings, the position of which is set by scales with reference to the edges of the plate; no templates are required. With an adjustable centre clamp, circles from 10mm to 600mm diameter can be cut out, again at any required distance from the

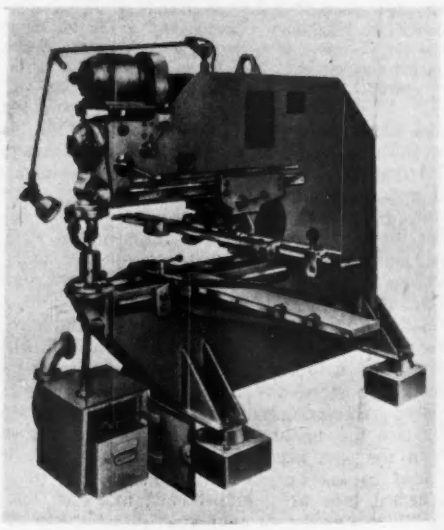


Fig. 30—Universal copying and co-ordinate nibbler. The sliding bracket attached to the upper part of the C-frame carries the material, the arm projecting from the lower part, the template. The copying feeler (spherical hand-grip) is on the right of the bracket—Trumpf and Co.

edge. The nibbling punch can cut 50 kg per square millimetre steel sheet up to 4mm thick ; without reclamping, sheets measuring up to 1150mm by 2000mm can be used. When copying, the operator has merely to run the copying feeler along the template which, it is stated, requires little effort. The machine is claimed to be of particular advantage in the production of small series for which press tools would be too expensive.

An automatic feed attachment for cutting rounds and strips, and operated by the punch movement, is also being put on the market.

Alfred Kärcher

An addition to its range of steam generators was shown by Alfred Kärcher, Winnenden, near Stuttgart (Fig. 31). The generator contains 26 litres of water and weighs 570 kg. It is a forced circulation monotube boiler and can evaporate 200 kg or 400 kg per hour (two stages) at 2-10 atmospheres gauge, corresponding to a saturation temperature of 133 deg.–183 deg. Cent.; superheating up to 220 deg. Cent. can be incorporated. Consumption of fuel oil ranges from 16 litres to 34 litres per hour depending on load. An electrical capacity of 1·2kW is installed. Besides a steam and water safety valve, the boiler contains a low water burner cut-out, ion exchange water softener and excess pressure switch which cuts off the burner if the pressure exceeds the preset value ; this renders the operation automatic. Another model shown for the first time was a trailer mounted cleaning unit designed to give 600 litres per hour of steam of 5 to 9 atmospheres and 140 deg. Cent., or 1200 litres per hour in a high pressure water jet at up to 20 atmospheres and 75 deg. Cent. The equipment is handled in this country by Sermac, Ltd., 211-217, Lower Richmond Road, Richmond, Surrey.

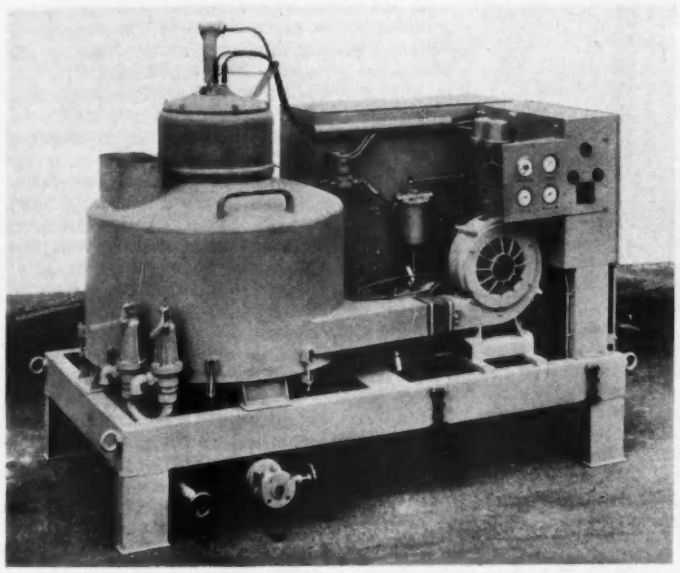


Fig. 31—200/400 kg per hour steam generator for up to 10 atmospheres gauge and superheat up to 220 deg. Cent. (cover removed)—Alfred Kärcher

Rheinische Stahlwerke

Thirteen of the subsidiaries of Rheinische Stahlwerke, Essen, were represented at Hanover, showing an impressive display of heavy and medium castings and forgings, semi-finished and completed components, and machinery. Mention may be made of a rotor shaft for a 100MW generator weighing 36·2 tonnes and cast in chrome-nickel-molybdenum electro-steel, degassed by the Ruhrstahl-Heraeus process (circulation of melt through a vacuum syphon chamber) (Ruhrstahl A.G., Hattingen). A continuously-cast mould for centrifugally casting bronze propeller shaft tubes was shown by Rheinstahl Eisenwerke Gelsenkirchen A.G. This casting, made of low-phosphorus grey cast iron with addition of hematite, weighed nearly 7 tonnes and had internal and external diameters of 660mm and 730mm, and a length of 10,020mm. This is stated to represent about twice the length obtainable with the traditional method of casting.

Messwandler-Bau-G.m.b.H.

The increased use of moisture-insensitive, mechanically strong epoxy resins for insulating high-tension electrical equipment has led to neater designs and considerable savings of space. This was exemplified by many exhibits, including those of Messwandler-Bau-G.m.b.H., Bamberg, Nürnbergerstrasse 225, which showed a combined voltage and current transformer for 110kV, in which all insulation and insulators were made of this material, as well as the outer protective casing which was centrifugally cast.

Loher and Söhne G.m.b.H.

On the stand of Loher and Söhne G.m.b.H., Ruhstorf/Rott, were shown electric motors for lifts and materials hoists. Fig. 32 shows such a motor with square fabricated housing which facilitates the mounting on top of a cooling fan. Since the starting current of lift motors amounts to 3 or 3·5 times the normal current, it is the starting frequency and acceleration which determine the size of motor required in any particular installation. Without independent forced cooling by means of a fan or blower, the starting frequency lies in the region of 120 to 180 starts per hour. In the motor illustrated, cooling air is drawn in from both ends, partly by rotor-mounted fans, partly by the independent fans. The square shape of the casing facilitates cooling the stator sides. The symmetry of the casing makes it possible to fit the terminal box or the fan at any of the sides or on the top, as shown here. For the insulation a tape made of inorganic materials, such as glass or asbestos fibre, and silicone resin, is used which has excellent mechanical and electrical properties. Heat conduction and mechanical protection is increased by encasing the stator coil ends in cast silicone rubber.

A synchronous generator regulated by a magnetic amplifier was claimed to have a particularly small time constant. The generator has coupled to it an exciter equipped with a permanent-magnet rotor and having a very flat voltage characteristic. This design does not have any brushes and does not require maintenance; in addition there is a saving in length. The medium-frequency, single-phase exciter current is rectified and applied to the generator rotor and to the main windings of a magnetic amplifier. The two control windings are connected in opposition to a generator output transformer, rectifiers, and a linear and non-linear resistance respectively. The linear resistance is variable and allows the required voltage to be set. Two further control windings are employed, one to feed back the generator rotor voltage, the other negatively to feed back the rotor current. Both feed-backs are adjustable, and permit the characteristic of the generator to be varied from astatic (single operation) to static (parallel operation). Output voltage is stated to be constant to better than ±1 per cent.

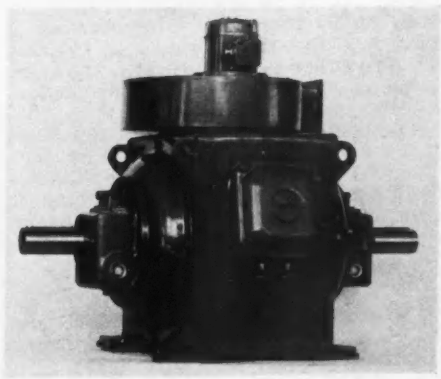


Fig. 32—Hoist motor with separately-driven cooling fan to permit frequent starting. The square casing allows fan and terminal box to occupy different positions—Loher and Söhne

Karl Frank

In the section devoted to testing machines, Karl Frank G.m.b.H., Weinheim-Birkenau, showed an electronic tensile testing machine (Fig. 33) for a maximum testing force of 1000 kg. The upper clamp is suspended from the measuring system (strain gauges). The lower clamp is operated by a screw spindle with steplessly variable drive. Test speeds can be adjusted between 5·5mm and 1000mm per minute (or higher in special cases). A quick return of 1500mm per minute is available ; for hysteresis tests the upward and downward speeds are identical. The total measuring range is subdivided into eight ranges, for each of which an accuracy of ±1 per cent or better is guaranteed from one-fifth full scale upwards. Readings are shown on a 300mm diameter dial, and may be recorded.

A Mooney shear plastometer with pneumatic closure of the test chamber and synchronous electric drive measures the plasticity of natural and synthetic rubbers as well as the vulcanising time (scorch time). Temperatures during testing are stated to be constant to within ±0·2 deg. Cent. The 84·6mm diameter test rotor is removed by an ejecting mechanism after the test.

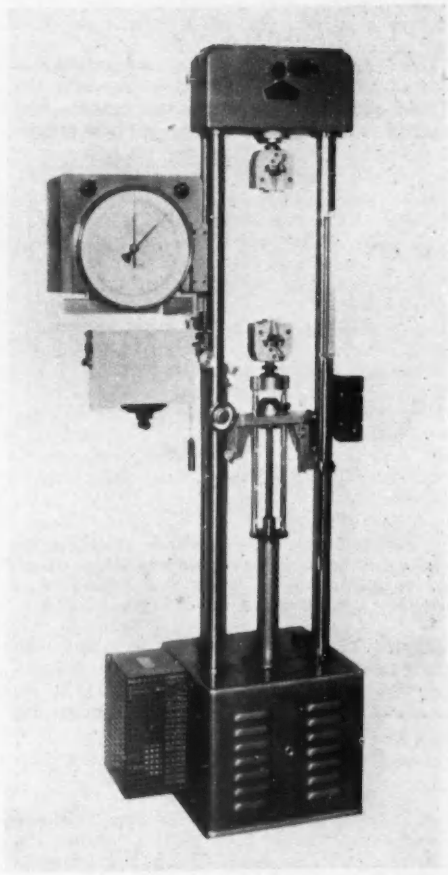


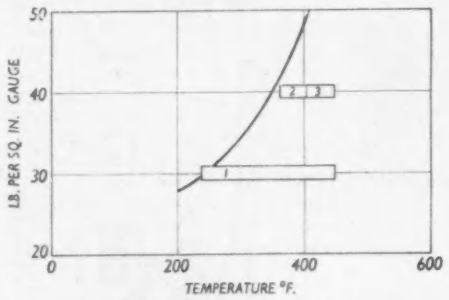
Fig. 33—1000 kg electronic tensile testing machine —Karl Frank

Borsig A.G.

On the stand of Borsig Aktiengesellschaft, Berlin-Tegel, was shown the model of a 200 ton per hour boiler designed for stop valve conditions of 140 atmospheres and a temperature of 530 deg. Cent. The boiler is unusual in being a horizontal design, and is described as a "W-boiler" on account of the shape of the end sectional elevation; there are two combustion chambers and a central partition divides the boiler as far as the superheater. Each combustion chamber is of the Borsig-Steag wet bottom design, with nine roof-mounted burners, the shape of the chamber being arranged so that the hot gases enter the heating surfaces horizontally. In order to reach the high flame temperature required to melt the ash, the secondary air is preheated not only by a Ljungström air heater but also by a tubular heat exchanger. The efficiency of the boiler is stated to be 90 per cent at 140 tons and 200 tons per hour, reaching 91 per cent at the normal load of 177 tons per hour. This is the second of three similar designs installed at the Bewag power station of Berlin-Moabit and dates from 1957. The other two are dry-bottom boilers.

Atlas Copco

The "Air Partner" mobile compressor was shown by Atlas Copco in two sizes, for deliveries of 10·5 and 17·5 cubic metres per minute. This is stated to be the first mobile screw compressor



1. Pratt and Whitney "JT-3," "JT-4," Rolls-Royce "Conway"
2. Allison "T-501"
3. General Electric "CJ-805"

Fig. 34—At a mass flow of 120 lb per minute the efficiency of the Lysholm compressors is high enough for the delivery to be cooler than desired on a standard day—Atlas Copco

designed for supplying jet airliners with compressed air for starting and air-conditioning. The first units of this kind (Fig. 34) came into service in April with the Scandinavian Airlines System.

Frieseke and Hoepfner

A number of accessories for the "Lukas" universal hydraulic tool system, shown by Frieseke and Hoepfner G.m.b.H., Erlangen-Bruck, enable further classes of work to be carried out. In one application, the flaring of holes in steel pipes of up to 30mm wall thickness and over in preparation for the welding-on of branch pipes, a taper mandrel is pushed through hydraulically from the inside. The rim of the hole has previously been heated to forging heat. For smaller pipe sizes, where the bore cannot accommodate a pressure cylinder, the mandrel can be attached to a yoke and pulled through by means of pressure cylinder placed under the yoke on either side.

Festo Maschinenfabrik G. Stoll

A four-sided automatic planer-moulder shown by Festo Maschinenfabrik G. Stoll, Esslingen a.N., is stated to profile without prior smooth planing. Even 1·5m long sash bars with a distortion of 4mm to 5mm can be profiled to a degree of straightness accurate to 0·2mm. The machine can plane pieces up to 2·5m long; its motors (four or five in number) can tilt from 0 deg. to 25 deg. and 35 deg. respectively, so that a wide range of profiles can be machined. Agent in Great Britain is Guilliet, Sons and Co., Ltd., 28-30, Rivington Street, London, E.C.2.

Delle

Our illustration (Fig. 35) shows a compressed air breaker for the first 525kV transmission. The equipment, which is over 14m high, was exhibited by the maker, Ateliers de Constructions Electriques de Delle, 25, Chemin de Cyprian, Villeurbanne (Rhône). It has a

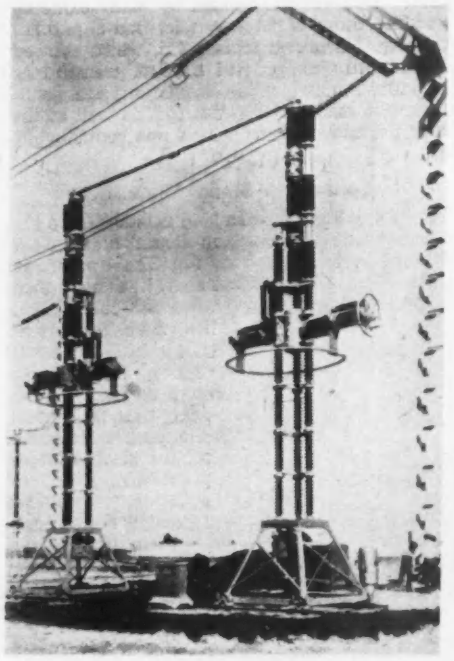


Fig. 35—Air circuit-breaker for 525kV, 2000A—Delle

nominal current capacity of 2000A and a breaking capacity of 2500MVA, equivalent to an effective current of 29,000kA. The breaker is stated to have a very low air consumption, requiring only 12,000 litres for a complete "on-off-on" cycle. Air pressure is 18·6 atmospheres. The equipment is intended for a Russian transmission line which is being converted from 400kV to 525kV. The breaker is stated to be a combination of main chambers equipped with voltage-dependent resistors, and auxiliary chambers for the damped current.

Losenhausenwerk

For testing large structural components (fuselage and bridge sections, prestressed concrete units) under cyclically varying loads, Losenhausenwerk, Düsseldorfer Maschinen-bau A.G., Düsseldorf - Grafenberg, Schlüterstrasse 19, showed oil-hydraulic units which can be steplessly adjusted to up to 120 loading cycles per minute. In contrast to the usual kind of pulsator, it is stated, the "SBE" units are supplied with hydraulic fluid (oil) not volumetrically but until the pre-set maximum pressure is reached. The delivery of the pump is then reversed until the minimum pressure is attained. Elastic energy liberated by the unloading is stored in a flywheel. It is possible, by using additional equipment, to apply reversing loads. Several groups of units can be operated in parallel in synchronism with identical or different load limits, and with any phase displacement required.

An optical attachment for piezo-electric balancing machines shows vectorially on two graduated screens the out-of-balance forces in two reference planes.

Elmeso Werkzeugfabrik

For securely gripping cylindrical and taper components on a machine or bench vice, Elmeso Werkzeugfabrik Elfried Mengel, Solingen-M., P.O. Box 44, has introduced jaw blocks provided with a series of vee-notches, both vertical and horizontal, in one face, and a flat surface on the other. The blocks are attached to an existing vice by drilling two holes into each jaw to insert the swivelling dowel on each block.

Process for Coal and Mineral Treatment

Arrangements have been made recently whereby Head Wrightson and Co., Ltd., becomes licensee for the "Stripa" process in the United Kingdom and the Commonwealth (excluding Canada). The exploitation of the process will be in the hands of the company's subsidiary, Head Wrightson Colliery Engineering, Ltd., who will use it in conjunction with the Stamicarbon (D.S.M.) processes which, it is stated, have already been incorporated in many successful plants. The process was developed at the Stripa Mine in Sweden, controlled by Staellberge Grufveaktiebolag, where high grade iron ore concentrates are produced. It has since been shown that the method can be used for the cleaning of coal. So far seven plants have been installed in recent years in the iron ore district of central Sweden.

In the process a convenient separating medium (a suspension of magnetite or shale, for example) is fed to a shallow reciprocating trough and the mineral to be treated is added a short distance from the medium feed point. The medium is concentrated to some extent in the trough; a floating fraction and a sinking fraction are discharged separately at the end of the trough, the cut between them being made by an adjustable splitter plate. The solids for the medium can be fairly coarse, and medium recovery is therefore very simple. Further development, both for minerals and coal, is being undertaken jointly by Head Wrightson Colliery Engineering, Ltd., and the Dutch State Mines. It is considered that coal can be separated at high densities, and that the separators will have a high capacity: it is also stated that economical plants can be designed embodying both "Stripa" and cyclone washing units and suitable for both ore and coal treatment. The matter of licence agreements and the co-ordination of the activities of the various contractor licensees is in the hands of Staellberg-Stripa, Ltd., of Toronto. Applications in the Scandinavian countries are being dealt with by the staff of Stripa Mine in co-operation with Swedish engineering sub-contractors; licensees have been appointed in Canada, U.S.A. and the Continent of Europe.

Petroleum Equipment Congress

The Third European Congress on Petroleum Equipment, organised by the Federation of European Petroleum Equipment Manufacturers, is being held in Paris from June 22 to 25. Twenty papers will be presented in English, French and German simultaneously, covering the subjects: "Safety in Refining Operations," "Transport and Distribution of Petroleum Products," and "Drilling Techniques and Equipment." In addition there will be a social and ladies' programme. Visits will be made to oil installations, refineries, oil fields and petroleum equipment manufacturers' works. Visitors to the Congress will also be able to attend the International Convention of Chemical Engineers, which is being held at the Maison de la Chimie at the same time. Inquiries should be addressed to Mr. G. C. Carr, Technical Adviser to the Council of British Manufacturers of Petroleum Equipment, 2, Princes Row, London, S.W.1.

German Welding Congress

The general theme of this year's principal technical congress of the German Welding Association will be "Welding and the Production of Energy." The Congress will be held in Berlin during the period June 23–26. Lectures will be given in German and will be followed by discussion; they will deal with the various reactor designs, their materials and welding problems; special problems in electric power transmission; welding in pipe construction; and new developments in the field of large turbine and generator construction. Altogether eighteen papers are to be presented. Those interested in obtaining a detailed programme and enrolment forms are asked to write to the Deutscher Verband für Schweisstechnik e.V., Düsseldorf, Harkortstrasse 23.

American Nuclear Engineering Conference

No. II—(*Continued from page* 787, *May* 15)

The fifth Nuclear Engineering and Science Conference was held at the Public Auditorium in Cleveland, Ohio, from April 5 *to* 10, *in conjunction with the* 1959 "*Atomfair*" *exhibition. The conference was organised under the sponsorship of the Engineers Joint Council in co-operation with twenty-seven American and Canadian engineering institutions. The exhibition was sponsored by the Atomic Industrial Forum and presented a comprehensive picture of the current state of development in the application of atomic energy in American industry.*

Sodium-Cooled Reactors

LIQUID sodium has several potential advantages as a reactor coolant. It is an excellent heat transfer medium ; it boils at a high temperature, permitting manufacture of high quality steam without coolant presssurisation, and it does not react with uranium. The disadvantages of liquid sodium coolant are its chemical reactivity with water and oxygen, and the radioactivity of the sodium isotope created by neutron bombardment. Operating problems originate primarily from the fact that reliable and economical equipment for handling high temperature sodium has not yet been developed. The Sodium Reactor Experiment (SRE) built by Atomics International for the A.E.C. at Santa Susana, California, is designed to produce 20tMW (Fig. 9). The associated equipment installed by the Southern California Edison Company produces and distributes about 6000kW of electricity. The SRE went critical in April, 1957. Initial operation was held to a fraction of full power, because of the high thermal stress to which certain components would have been subjected had a full power scram occurred. After the installation of an eddy current brake in early 1958 to cut down the flow of sodium in case of a scram, full power operation was attained and has been continued during a major portion of the last six months.

Atomics International, under a Commission contract in the Power Demonstration Reactor Programme, continued during 1958 with design and development of a 75,000ekW high temperature sodium-cooled, graphite-moderated reactor to be built on the grid of the Consumers Public Power District at Hallam, Nebraska. A groundbreaking ceremony was held in June for the conventional part of this plant, called the Hallam Nuclear Power Facility. Reactor construction is scheduled to begin this year, with a completion target date for the reactor in 1961.

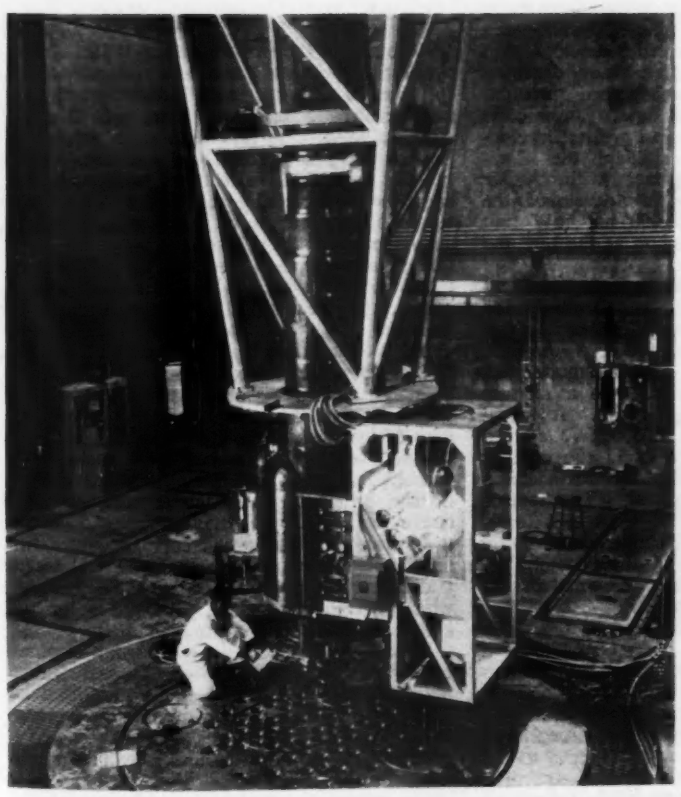
The Nuclear Development Corporation of America (NDA) is carrying out research and development and preliminary design of a 10,000ekW sodium-cooled, heavy-water-moderated reactor, which, if proved feasible, would be built for the Chugach Electric Association, Incorporated, at Anchorage, Alaska, under the Power Demonstration Reactor Programme. NDA is also doing conceptual design studies on a considerably larger natural uranium-fuelled, sodium-cooled heavy-water-moderated power plant to determine the economic feasibility of such a plant. In order to utilise to best advantage the high temperature capabilities of sodium coolant, the Commission is following two parallel and complementary lines of research and development in addition to the construction and operation of reactors. The first line is the development of high-integrity, high-burnup, high-temperature fuel elements ; the second is the development of reliable, less expensive components to handle liquid sodium. A thorium-uranium core is being fabricated for installation in the SRE when the present core requires replacement. Research and development programmes for improved fuels are in progress and samples of uranium-molybdenum fuels and uranium carbide fuels are being tested in the SRE and elsewhere. This fuel development work also is directed toward the needs of the Hallam plant. The first core loading of the plant will be an uranium-molybdenum alloy fuel instead of uranium oxide, as originally planned. Limited irradiation tests of dense uranium carbide, made by arc-welding and casting, have led to a preliminary conclusion that it also has substantial promise for high-temperature reactors. Further work will be done on this fuel in the hope that it may be used in the second Hallam core.

Fast Breeder Reactors

Fast reactors occupy an important place in a nuclear power programme because their ability to produce more fuel than they consume is potentially important to the conservation of fissionable material resources. A fast reactor does not use a moderator to slow down the neutrons, but operates on fission by fast neutrons. Characteristically it has a compact core of highly enriched fissionable material and requires a highly efficient coolant such as sodium. The first American experimental fast reactor was the Experimental Breeder Reactor No. 1, which has been operated at the National Reactor Testing Station since 1951. With its first core, the EBR-1 demonstrated that breeding is feasible in a fast reactor. Operation with its second core in 1955 was terminated during an experiment by a power excursion which resulted in partial meltdown of the core. Successful operation during 1958 with a redesigned third core indicated that the excursion was caused in part by an insufficiently rigid core structure. After extensive experiments with both rigid and non-rigid cores, the A.E.C. plans to test plutonium fuel elements in EBR-1.

The construction of an additional facility for testing the safety of fast reactor systems, the Transient Reactor Test Facility (TREAT), was completed in October at the National Reactor Testing Station. The primary objective of TREAT is to provide data on the mechanism of melting of fuel elements by nuclear heating, and initial experiments will be directed toward fast reactor fuel pins. The second major experimental power reactor in the Commission's fast reactor programme is the Experimental Breeder Reactor No. 2, a 16,500 net ekW plant now under construction at the National Reactor Testing Station. The reactor is scheduled for dry criticality in May, 1960. Both EBR plants were designed by the Argonne National Laboratory, which also operated EBR-1.

A fuel reprocessing and fabrication facility is included as an integral part of the installation. EBR-2 will be the first reactor in the United States to operate on a closed, pyrometallurgical fuel cycle. Thus, for the first time, it will be possible to evaluate the technical and economic



Figs. 9 and 10—(Left) 20tMW sodium reactor experiment of Atomics International at Santa Susana, California. (Right) Current construction progress at the Enrico Fermi atomic power station of the Power Reactor Development Company near Detroit

advantages associated with pyrometallurgical processing of core elements and their fabrication by remote handling equipment on the basis of actual operating experience. EBR-2 will also demonstrate the operation of large-scale sodium components, such as pumps and heat exchangers, under pressure and temperature conditions comparable to those required for high performance, full-scale reactors.

Operating experience with a large-scale fast reactor will be provided by the 90,000 net ekW Enrico Fermi plant (Fig. 10) at Lagoona Beach, near Monroe, Michigan, which is scheduled for completion in 1960 by the Power Reactor Development Company under the Power Demonstration Reactor Programme. Most of the heat and about one-fourth of the new fuel (plutonium) is produced in the reactor core, which is an assembly of alloy pins containing uranium that is partially enriched in U-235. Surrounding the core is a breeder blanket of alloy rods, containing uranium that is depleted in U-235; nearly three-fourths of the new fuel is produced here. Eventually the plutonium produced will be used as fuel for the reactor. Heat is removed from the reactor core and blanket by circulating liquid sodium. It is transferred to a secondary sodium system in intermediate heat exchangers and is then transferred to water and steam in "once-through" steam generators. Steam is utilised in a conventional steam turbine that is directly connected to an electric generator. Loading or unloading the core and blanket is accomplished by a handling system that consists of a rotating shield plug and an offset handling mechanism. A hold-down plate is situated below the plug to maintain radial alignment of the core elements and to hold them down against the pressure caused by the up-flow of coolant through these elements. This plate also acts as a guide for the control element drives. The reactor control system consists of instruments and other devices integrated with the steam plant control system to provide stable operation of the entire plant; the overall control system is so designed that reactor power level is controlled by the load on the turbo-generator. Neutron absorbing rods (boron-10) are used to control the power level of the reactor or to shut it down.

A major variation in fast reactors, the use of oxide fuels, is being investigated as a continuation of preliminary research carried out at the Knolls Atomic Power Laboratory. Oxide fuel, which is used extensively in water reactors, permits longer exposure and higher burnups before the fuel must be reprocessed, thereby reducing fuel reprocessing and refabrication costs.

Fluid Fuel Reactors

Several reactor concepts which utilise fluid fuels have been under development in America. They include the aqueous homogeneous concept, which uses solutions or suspensions of fuel in heavy water; the liquid metal fuel concept, in which uranium dissolved in molten bismuth flows through a graphite matrix; and the molten salt concept, which employs uranium fluoride dissolved in a mixture of lithium and beryllium fluorides. Aqueous homogeneous reactors, by combining fuel, moderator and coolant in a solution, by-pass problems of fabrication and stability of fuel elements and make possible such desirable characteristics as high power density, low fuel cycle cost, and the continuous removal of fission products. Disadvantages inherent in the aqueous homogeneous concept include increased fuel containment problems, corrosion problems, the circulation and handling of large quantities of radioactive materials, and the extensive use of remote maintenance techniques. The first Homogeneous Reactor Experiment (HRE-1) was fabricated at Oak Ridge National Laboratory during the period 1950–52. It had a thermal output of 1MW and was designed primarily as a physics experiment to explore the characteristics of a reactor containing a circulating uranyl sulphate fuel solution. It went critical in April, 1952. After numerous tests, it was dismantled in the spring of 1954, and work was begun on a larger and more advanced aqueous homogeneous reactor at the same site.

Homogeneous Reactor Experiment No. 2 went critical in December, 1957. After critical and low power-level experiments, the reactor was gradually brought up to its full design power of 5tMW in April, 1958. Shortly thereafter, instruments indicated that fuel from the main core region was transferring to the heavy water reflector region and that a failure had occurred in the core tank. The plant, which had operated stably at design conditions, was shut down for examination. While specialised examining equipment was being developed, the reactor was operated until September 12 with fuel solution in both the core and blanket regions, the concentration in the blanket being kept at low level by continuous purge. During this period 2·5MWh of heat were generated in 1074 hours of operation which was trouble-free mechanically, but was characterised by occasional brief fluctuations in power level.

A complete inspection of HRE-2 in September disclosed an oval hole measuring about 1½in by 1in in the core tank, a general thinning down of the core liner, and extensive corrosion attack in the region of the diffuser screens which distribute the flow of fuel solution at the reactor inlet. Metallurgical examination of samples from the diffuser screens indicated that very high temperatures had been developed in the metal. The evidence is that the observed power fluctuations, the high temperatures and the corrosion are caused by an instability of the fuel solution which results in concentrations of fuel in certain areas. HRE-2 operation has now been resumed at reduced power, and major attention is being given to correcting the difficulties.

Development work on the liquid metal fuel system was carried out during 1958 by the Brookhaven National Laboratory and the Babcock and Wilcox Company. This system has the advantage of combining a high temperature with a low pressure in the primary system. An inherent disadvantage is the complications resulting from the high melting point of the metal. The development work consisted primarily of experiments with thermal test loops and critical and subcritical assemblies.

Gas-Cooled Reactors

Gas-cooled reactors can operate at high coolant temperatures with correspondingly high thermal efficiency. The major disadvantage of this reactor system is its relatively high capital cost. Much of the early technology for civilian high-temperature reactors has been obtained from the military reactor programmes. In August, 1957, the A.E.C. initiated a study of a gas-cooled, graphite-moderated reactor, fuelled with natural uranium. This study disclosed that the use of partially enriched uranium would result in significantly lower power costs in this type of reactor and had greater development possibilities. Accordingly, the Commission, through a contract with Kaiser Engineers–ACF Industries, has developed the conceptual design of a 26,000 net ekW unit using slightly enriched uranium as the fuel and helium as the coolant.

In response to an invitation from the Commission, the Philadelphia Electric Company and the General Atomic Division of the General Dynamics Corporation submitted a proposal for a high-temperature, graphite-moderated, helium-cooled reactor, fuelled with a mixture of enriched uranium and thorium. It would have an initial output of 28,500ekW, later to be increased by improvements in the core to 40,000ekW, to be fed into the Philadelphia Electric Company grid system. The reactor would be designed by the General Atomic Division of the General Dynamics Corporation and would be constructed by the Bechtel Corporation under a fixed-price contract in the amount of 24,500,000 dollars.

Heavy Water Reactors

The use of heavy water, an efficient moderator, in power reactors is attractive principally because it permits the utilisation of natural uranium as fuel without dependence on enriched uranium. The high cost is a deterrent to the use of heavy water in power stations. The Commission in 1956 undertook additional research and development and analysis of design studies to provide a basis for proceeding with a large-scale reactor project of this type. E.I. du Pont de Nemours and Co. completed a preliminary study in January, 1957, which indicated that construction of a large plant was feasible. du Pont has continued its studies in heavy water technology and is executing a preliminary design for a Heavy Water Components Test Reactor (HWCTR), a facility for test irradiation of full-size natural uranium fuel elements and other components under power reactor operating conditions. The HWCTR is to be unclassified and will be situated within the classified Savannah River Plant in such a way as to permit unclassified access by both United States and foreign representatives. The design should be completed by November, 1959. The Carolinas–Virginia Nuclear Power Associates, Incorporated, has proposed to build at Parr Shoals, South Carolina, a reactor cooled and moderated by heavy water, using pressure tubes instead of a pressure vessel and utilising slightly enriched uranium. The planned output will be 16,950ekW. Negotiations were completed late in 1958 between the Commission and the Associates for a contract under the Power Demonstration Reactor Programme and it was signed on January 12, 1959.

Maritime Reactors

The final design and fabrication by the Babcock and Wilcox Company of the pressurised water power plant for the first nuclear-powered American merchant ship, the N.S. "Savannah," continued during 1958 in accordance with the schedule established. Criticality is scheduled for early 1960 with sea trials soon thereafter. Experimental irradiation of the first test fuel element was begun in August and proceeded without incident. Engineering development work on a replacement core for the "Savannah" and the irradiation of prototype fuel elements for the core are being undertaken by The General Electric Company at San Jose, California. The ship is taking form on the building ways at the Camden, New Jersey, yard of the New York Shipbuilding Corporation. The States Marine Corporation of Delaware was selected by the U.S. Maritime Administration as the operating agent during Phase I, the initial experimental period, and Phase II, the national and international operation in modified commercial service for evaluation purposes. Babcock and Wilcox is now training the "Savannah" engineering crew in reactor theory, engineering and operation.

Progress in Fuel Elements

Recognising the importance of reducing fuel cycle costs as one of the means available to-day for providing lower cost nuclear energy, a number of programmes are being undertaken in America to develop new techniques which will provide lower-cost solid fuel elements, longer life for these fuels in reactors, and lower-cost spent-fuel reprocessing techniques. Although technological changes in any one part of the solid fuel cycle unquestionably affect the technology in other parts, it seems that the key item in the entire fuel cycle is the basic design of the nuclear fuel element. The composition of the fuel core, the kind of cladding used, the nature of the bonding materials, of closures and end fittings which are employed, the degree of enrichment used, the fuel shape and the method of fuel assembly, all have an important bearing on each of the steps in the nuclear fuel cycle. The criteria used in the design of the nuclear fuel element will govern, to a great extent, the cost of the basic raw material procurement and conversion, the cost of the fuel fabrication, and the degree of burnup and corrosion resistance achievable in a reactor. Finally, the fuel design and its material composition are the key factors which govern the degree of expense for the chemical reprocessing of the fuel.

In the field of plutonium production reactors, the basic fuel employed both in the United States and overseas comprises a natural uranium metal rod or slug, clad in aluminium or magnesium. This kind of element has provided excellent service for the use to which it has been put; nevertheless its basically simple shape limits the specific power level of the production reactors and, hence, the plutonium generation. Increasing the surface-to-volume

ratio of the fuel slugs or rods would provide for greater heat transfer and thereby enable these reactors to operate at higher specific power levels without increasing the maximum central temperature of the fuel. This is basically the reason for the trend towards hollow slugs or tubular fuel elements which permit coolant flow both inside and outside the fuel. The desire to achieve high specific power levels in these reactors also explains the increasing interest in the use of zirconium claddings as replacements for the lower temperature aluminium and magnesium claddings.

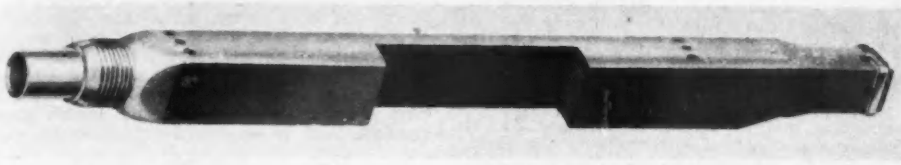


Fig. 11—MTR-type of standard fuel element, with eighteen uranium-aluminium plate cores

Until quite recently, fuels for research and test reactors have followed a fairly definite pattern, employing the " MTR " fuel design with variations in the number of plates used and in the design of the end boxes (Fig. 11). For the most part, research and test reactor fuels have comprised uranium-aluminium alloy flat plate cores, clad in aluminium and brazed into a box assembly. The number of plates in each box assembly varies from ten to eighteen, depending on the amount of uranium used and the resultant fuel element is not unlike in appearance the " MTR " element. The reactor performance of this kind of fuel has been very encouraging, and the UO_2-stainless steel matrix composition has shown itself capable of providing high specific power outputs with fairly high uranium burnup.

In the gas-cooled package reactor, the basic " APPR " fuel design may prove acceptable as a starting point ; however, the efficiency of gas-cooled reactors increases materially as temperature levels increase, and it is quite probable that materials other than stainless steel will ultimately be considered. Furthermore, there is some question as to whether the plate and box design

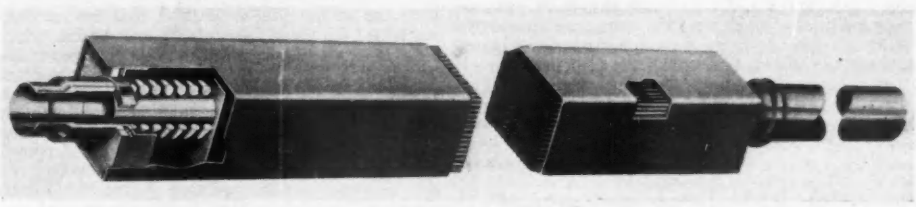


Fig. 12—Uranium oxide fuel element with stainless steel cladding for Indian Point pressurised water power reactor

purpose of the reactor. Until recently fuel elements assembled by brazing techniques have proved entirely satisfactory for the relatively low power levels and low water flow rates used in the research and test reactors. However, for a growing number of high-powered test reactors, the braze assembly of box-type fuel elements has proved unsatisfactory. Among the problems encountered with brazed assemblies have been their inability to withstand fast water flow rates. This limitation arises from the fact that during the brazing operation, the aluminium anneals, having virtually no strength to retain its shape when large water flow stresses are applied. Brazed elements also suffer from residual lithium left over from the braze flux, and the possibility of braze corrosion when these elements are left in reactors for an extended period of time.

To overcome the problems of brazing, a number of mechanically assembled " MTR " fuel elements have recently been developed and introduced by the Sylvania-Corning Nuclear Corporation. These assemblies, which have the fuel plates mechanically fastened instead of brazed to the side plates, have considerably more strength and rigidity. This is because assembly of the fuel element is done at room temperature so that the resultant fuel element maintains the stiffness and rigidity of the cold-rolled aluminium plates. This additional rigidity has permitted mechanically assembled fuels to be operated for sustained periods at water flow rates well above 40ft per second without distortion of the element. The lack of brazing in mechanically assembled elements also precludes the possibility of lithium contamination of the element, a factor which has proved to be of considerable importance in heavy-water-moderated reactors.

In the field of package power reactors, and particularly package reactors of the " APPR " is the most efficient form for gas-cooled systems; hence, more complex geometric configurations will be considered so that optimum heat transfer and pressure drop conditions can be achieved.

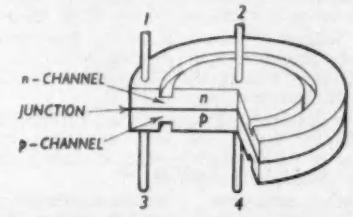
Finally, in stationary power reactors, uranium oxide fuel cores, clad with either stainless steel, Zircaloy or aluminium, are preferred at the moment (Fig. 12). Elements of this kind have offered considerable promise in providing the kind of fuel which is necessary to the economics of large-scale nuclear power generation. Burn-up data have been most encouraging, and there seems to be a growing confidence that UO_2 fuels will ultimately provide considerably more than 10,000 MW-days per ton of burnup. Uranium oxide fuels offer an additional major advantage in the fuel cycle. This advantage accrues from the fact that uranium oxide fuels can probably be reprocessed at relatively low cost.

(To be continued)

Semi-Conductor Field-Effect Tetrode

A NEW four-terminal semi-conductor device, which will perform a number of electronic functions which previously either could not be obtained at all, or only with extensive circuitry, has recently been invented at the Bell Telephone Laboratories. The device is called the field-effect tetrode and can be made to function as a transformer, gyrator, isolator, non-distorting modulator, or a short-circuit stable negative resistance. Laboratory models have been produced by the inventors, H. A. Stone, Jr., and R. M. Warner, Jr., which corroborate the theoretical predictions for the operation of the device. This theory grew out of work previously reported on a field-effect current limiter. The tetrode is composed of a disc of semi-conductor with a diffused junction. A circular trench is cut and etched into each face of the disc, to within about 0·001in of the junction on either side. Two leads are then attached to each face, one inside the trench, the other outside. When a voltage is applied across the junction, the thickness of the depletion layer adjacent to it is increased or decreased, depending on the direction of the biasing voltage. This in turn increases or decreases the resistance of each " channel " between the bottom of the trench and the junction.

Functionally, the device has no analogue, either in electron valves or in previous transistors. The tetrode will function either as a transformer or a gyrator, depending on the polarity of the biasing voltage. As a transformer, it has a very decided size advantage for low-frequency use, although it does not afford d.c. isolation. As a gyrator, it should be of considerable circuit interest. (A gyrator is a non-reciprocal four-terminal network which behaves similarly to a transformer, while exhibiting a 180 deg. difference in phase shift, depending



Field-effect tetrode with diffused junction disc of semi-conductor material

on the direction of transmission.) One gyrator function is impedance inversion. For example, it should be possible to use the new device to convert the reactance of a miniature capacitor into that of a high-Q inductor. If the device is biased properly, it will function as an isolator, allowing passage of alternating current in one direction only.

According to its inventors, one of the most important applications for the new device may be as a distortionless modulator, or electronically controlled resistor for large signals. In this use, a relatively low-frequency control voltage varies the width of the depletion layer and thus the resistance of the device. Simple capacitors act as high-pass filters to isolate the control voltage from the signal, if the frequency ratio is maintained at a high level. The signal voltage does not appear across the junction and has no effect on the depletion layer. Therefore it can be magnitudes higher than the control voltage without being distorted by self-modulation. For the same reason, it is not limited by junction capacitance. If a direct connection is made between the inner lead on one face and the outer lead on the other, the device will function as a two-terminal a.c. short-circuit stable negative resistance. In the experimental models produced at the Bell Laboratories, this performance has been achieved over a range of 30V to 250V, at 0·6mA to 0·1mA in a boron-doped silicon crystal with a phosphorus-diffused junction.

Aluminium Armour

A RECENT demonstration at the Aberdeen Proving Grounds of the United States Army Ordnance Corps emphasised that the use of aluminium is contributing significantly to the air transportability of equipment and thus to strategic mobility. An example was the 8 by 8 Chrysler XM-410 2½-ton truck, which weighed less when fully loaded than the present 2½-ton truck empty, i.e. 6 tons 12 cwt; this not only facilitated air transport and parachuting of the vehicle, but allowed it to float, if desired, when lakes or deep rivers were to be crossed ; the tail gate incorporated special extrusions designed by Reynolds Metal Company to render it watertight. Aluminium armour plate gave the same protection as steel for a reduced weight in the M-113 air-portable armoured personnel carrier. Another advantage of aluminium was its freedom from brittle fracture in Arctic temperatures ; it is incorporated in the T-116 cargo carrier intended for use on snow and mud.

Personal and Business

Appointments

MR. R. E. DAVIS has been appointed sales manager of Petbow, Ltd.

MR. CARL J. MAKI has been appointed assistant to the executive vice-president of Dresser Industries Inc., Dallas, Texas.

MAVOR AND COULSON, Ltd., has announced that Mr. Cargill S. Sandeman has been appointed to the board of directors.

MR. C. W. CLARKE has been appointed home sales manager of the Surform division of Simmonds Aerocessories, Ltd.

ROSITE, Ltd., Cheney Manor, Swindon, Wilts, announces that Mr. James Bent has joined the company as sales engineer.

MR. J. W. BOOTH has been re-appointed to be a part-time member of British Overseas Airways Corporation until April 30, 1962.

DR. ROBERT T. PARKER has been appointed head of Aluminium Laboratories, Ltd., Banbury and Geneva offices in succession to Mr. R. D. Hamer.

SIR WAVELL WAKEFIELD, M.P., has been re-appointed president of the Electric Vehicle Association of Great Britain, and Mr. E. Powell has been appointed chairman.

FIRTH CLEVELAND FINANCE, Ltd., announces that Mr. A. H. Waller has been appointed branch manager of the company's office at County House, 45, East Hill, London, S.W.18.

LAMBHILL IRONWORKS, Ltd., announces the retirement of Mr. Wm. D. Fraser, M.I.Struct.E., a director of the company for thirty-four years. Mr. James McBride and Mr. J. W. Shearer have been appointed to the board.

THE FEDERATION OF CIVIL ENGINEERING CONTRACTORS has announced that Mr. J. Maurice Laing has been appointed chairman in succession to Mr. E. C. Beck. Mr. A. J. Hill has been appointed vice-chairman.

AIR VICE-MARSHAL A. F. HUTTON, M.I.Mech.E., has joined Negretti and Zambra, Ltd., in an advisory and consultative capacity particularly in those fields of the company's products concerned with aircraft engineering and guided missiles.

MR. C. O. FARRER has been appointed plant development engineer of W. T. Henley's Telegraph Works Company, Ltd., in succession to Mr. F. T. Griffiths. Mr. A. R. Hutchinson has been appointed to succeed Mr. Farrer as works engineer at Birtley.

THE NORTH BRITISH RUBBER COMPANY, Ltd., has announced the appointment of Mr. T. S. Martin to the newly created post of field sales manager, industrial products division. He will operate from the company's sales office, 62-64, Horseferry Road, London, S.W.1.

THOS. W. WARD, Ltd., announces that Mr. D. C. Coates has been appointed general manager, contractors plant department (southern area), in succession to Mr. W. B. Spencer, who has relinquished the position on medical advice. Mr. E. L. Ward has been appointed sales manager.

THE BROCKHOUSE ORGANISATION announces the appointment of Mr. W. H. Solf as its European representative. He will be responsible for co-ordinating and supervising the Group's activities in this area and will be based at the London office of Brockhouse (Trading Facilities), Ltd., 25, Hanover Square, London, W.1.

MR. J. M. A. SMITH, assistant managing director of the Ford Motor Company, Ltd., has been elected president of the Society of Motor Manufacturers and Traders for 1959-60, in succession to Mr. Reay Geddes who now becomes deputy president. Mr. M. L. Breeden has been re-elected for a second term as a vice-president, and Mr. M. A. H. Bellhouse has been made a vice-president in succession to Mr. J. M. A. Smith.

Business Announcements

URQUHART LINDSAY AND ROBERTSON ORCHAR, Ltd., Blackness Foundry, P.O. Box 97, Dundee, announces that the firm is to close down at the end of May.

YOUNGS (LIFTING APPLIANCES), Ltd., states that its London office has moved from 39, Victoria Street, to 19-21, Goswell Road, London, E.C.1 (telephone Clerkenewell 9171-2).

FIRTH CLEVELAND FINANCE, Ltd., announces that it has opened a branch office at Corn Exchange Buildings, 19, Hanging Ditch, Manchester, 4 (telephone Deansgate 5253-4). It will be managed by Mr. E. Hibbs.

JOHN BARNSLEY AND SONS, Ltd., Netherton, Worcestershire, has appointed George Cohen, Sons and Co., Ltd., as sole agent in Scotland, Ireland and South Wales for Barnsley electric overhead travelling and Goliath cranes.

POLYPENCO, Ltd., 68-70, Tewin Road, Welwyn Garden City, Herts, has appointed the Norman Wrigley Company, Ltd., 366, Stretford Road, Manchester, 15, as its agent for north-west England, and Durward Clarkson and Co., Ltd., 137A, St. Vincent Street, Glasgow, C.2, as its agent for Scotland.

THE PLESSEY COMPANY, Ltd., Ilford, Essex, announces that an agreement providing for the manufacture of Metallux resistors in the United Kingdom has been concluded with Elettronica Metal Lux s.p.a., of Milan, Italy. In addition to sole manufacturing rights in Britain, Plessey will hold selling rights for the United Kingdom and all Commonwealth countries.

Miscellanea

PIPELINE SYSTEM.—The Shell Chemical Company, Ltd., announces that work has started on the laying of four underground pipelines to link the Stanlow refinery with the company's Carrington works, near Manchester, for the transfer of feedstock, chemical intermediates and finished products. In addition, two pipelines are to be laid for Shell-Mex and B.P., Ltd.

LIGHTING PROGRESS.—A brochure with the title "Lights Under Bushels," has been issued by George Bray and Co., Ltd., Leicester Place, Leeds, 2, which outlines the growth of the company during its ninety-six years of existence. Starting with the introduction of the porcelain-tipped gas lighting burner in 1863, the brochure mentions early developments, traces the pattern of changes over the years and comments on the current activities of the gas burner, insulator and electric heating divisions of the company.

TRANSISTOR POLARISING SUPPLIES.—Two new units, PNI1034 and PNI1042, are available from Plessey Nucleonics, Ltd., Weedon Road, Northampton, for polarising ionisation chambers used in the flux measuring channels of nuclear reactor instrumentation systems. The h.t. output, from 400V to 600V, is derived from a transistor-converter circuit and an alarm relay is provided which indicates failure of output or disconnection. A number of polarising supplies is normally operated from a common low-voltage secondary battery but individual miniature, sealed, secondary batteries could alternatively be mounted internally.

CONTACT LUBRICATION.—A fluid known as "Electrolube" is being marketed by the Electrolube Sales Company, 3, Red Place, Green Street, London, W.1, for the protection and improved conductivity of electrical contacts. "Electrolube" No. 1 contains a volatile solvent to act as a spreader and cleanser for the removal of foreign matter from contacts before evaporating. "Electrolube" No. 2 is the basic, undiluted fluid and is recommended where sparking is liable to occur at contacts on separation. Both fluids are chemically inert, free from carbon, and have a comparatively low electrical resistance for an oil, coupled with a negative resistance/temperature characteristic.

AUTOMATIC COPY-TURNING.—A demonstration of automatic copy-turning on the Swiss-built Dubied hydraulic copying lathe, "model 517," will be held by Wickman, Ltd., from Monday, May 25, to Friday, May 29, at Fletchamstead Highway, Coventry. High-production automatic copy-turning of medium-sized components, under entirely automatic control after loading, will be demonstrated by a new six-cycle attachment controlling length and depth of roughing cuts. On this machine up to five roughing cuts can be pre-selected, after which the copying cut under automatic feed control is engaged to complete the final form, with, if desired, one or two plunge cuts following the copying cut.

THE 1959 MOTOR SHOW.—The forty-fourth International Motor Exhibition will be opened at Earls Court on Wednesday, October 21, and will remain open until the evening of Saturday, October 31. For the first time there will be no display of boats or marine engines at the Motor Show, since the manufacturers concerned consider that their side of the industry will be adequately represented by the National Boat Show to be staged at Earls Court in January, 1960. Although a separate Caravan Exhibition (primarily of residential models) is to be held at Earls Court in September, 1959, the caravan section at the motor exhibition in October will be unaffected and will continue to be the showplace of the touring variety.

HEAVY-DUTY PORTABLE GRINDER.—A heavy-duty portable pneumatic grinder introduced by Atlas Copco (Great Britain), Ltd., Beresford Avenue, Wembley, Middlesex, is designed to take 6in, 7in and 8in wheels, and weighs only 12 lb. With a 6in wheel the spindle speed is 6000 r.p.m., with a 7in wheel 5100 r.p.m., and with an 8in wheel 4500 r.p.m., the respective air consumptions with these wheels being 90, 84 and 76 cubic feet per minute. The tool is fitted with a governor and an overspeed coupling which automatically disconnects the arbor spindle from the vane type motor should the governor fail. A double-action air intake valve on the grinder gives a smooth start and eliminates sudden torque reaction.

STEEL TOWN.—A new colour film produced by Wallace Productions, Ltd., for the United Steel Companies, Ltd., was shown for the first time in London earlier this month. Entitled "Steel Town," the film deals with a large steel works, Samuel Fox and Co., Ltd., and a small town, Stocksbridge, and portrays the close links which have been forged between them. The film presents a picture of work and play in a close-knit community which depends on heavy engineering for its livelihood. The making of special and alloy steels, from the arrival of the raw materials to the despatch of the finished products, is shown, the apprentice training facilities provided by the company are described, the works council is seen in action, and the Social Services Brass Band is shown at rehearsal. The film runs for twenty-five minutes and is available on loan in 16mm and 35mm sizes.

ELECTRICAL HANDBOOK.—A third edition has been published by J. A. Crabtree and Co., Ltd., Walsall, Staffs, of the electrical handbook which appeared first in 1941. So many changes have taken place in wiring materials and methods, and in regulations, since the second edition of 1947, that the company has issued the present completely new edition, which has 424 pages but, being printed on new paper and bound in a thin but durable plastic, is lighter and smaller than its predecessor, and more convenient for the pocket. Principal subjects dealt with are installation planning, wiring accessories and circuits, lighting, circuit protection, and motors and control gear. A number of sections has been added and the reference tables expanded. The "Crabtree Electrical Handbook" is published at 5s. and may be obtained through booksellers or from the head office of the company at Lincoln Works, Walsall, Staffs.

DECIMAL INDICATOR TUBE.—A cold cathode decimal indicator tube (type Z503M) has been introduced by Mullard, Ltd., Mullard House, Torrington Place, London, W.C.1, for use in the high-speed stages of counting equipments. Conventional hard valves or specialised tubes, like the trochotron, used for counting in such stages require some external indicating device, and the Z503M tube has the advantage of displaying the count in the same way as a decimal stepping tube, thus enabling the visual presentation to be made uniform throughout all stages of the counting equipment. The Z503M consists of an anode and ten cathodes, with each cathode brought out to a separate pin so that ten connections can be made to the counting circuit. The count is indicated by a glow discharge on the appropriate cathode. The tube gives "end-on" viewing of the discharge, the position of which can be identified by an external numbered escutcheon. It is mounted on a duodecal (B12A) base, and has a maximum seated height of 70mm and a maximum diameter of 33mm.

SHIP PLATE PRODUCTION.—On March 9, W. R. Mellanby read his paper "Optical Marking and Automatic Plate Production" before the North East Coast Institution of Engineers and Shipbuilders. The paper describes a new method for fabricating steel plates for shipbuilding in which one-tenth scale drawings are made of each plate and subsequently photographed, and the resulting glass negatives are then used either in a Monopol machine or an Optical Projector. Preparation of the drawings in the mould loft and the extent of the work are outlined, followed by notes upon the photographic department, the Schichau–Monopol machine and its control. The optical projector system is dealt with next and touches upon method of operation and degree of accuracy. Economic considerations of the new methods are given and figures are recorded comparing cutting speeds of the old system with those of the Monopol machine and the man-hours for marking off by the old method and the optical method. Production planning and control are discussed with reference to the information required, procedure, preparation of records and the initiation of fabrication.

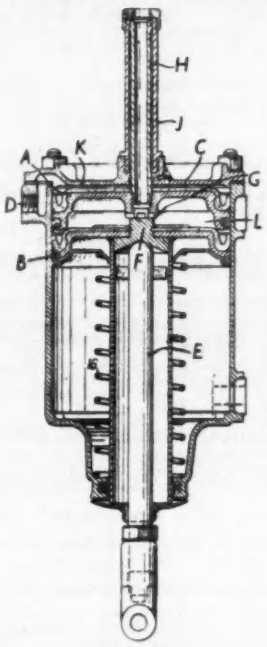
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

AUTOMOBILES

810,901. March 26, 1957.—BRAKING EQUIPMENT FOR VEHICLES, Compagnie des Freins et Signaux Westinghouse, 18, rue Volney, Paris 2e, France.

This specification describes a fluid pressure braking system, having two independent circuits, one being termed the "main brake" and the other the "emergency brake," and for both of which a single cylinder is used. As may be seen in the drawing, the device comprises a single cylinder in which are two



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pistons *A* and *B*. The piston *A* normally abuts, by means of projections *C*, against the top cover plate, a chamber being formed between the piston at its top position, and the cover plate. A fluid inlet *D* of the main brake opens into this chamber. The second piston *B* bears with a ball-and-socket joint on to a thrust rod *E* connected to the brake rigging (not shown in the drawing). In the inoperative condition, piston *B* is spring loaded against piston *A* through a central projection *F*. Between the two pistons a chamber is thus formed, into which the control fluid of the emergency brake flows through the apertures *G* formed in the central part of the piston *A*, this fluid being supplied through a pipe *H* screwed into a central bore in the piston. The other end of the pipe is slidable in an outer tube *J* secured to the cover plate and coupled, by a screwed cap, to the emergency brake circuit. Two seals isolate the chamber *K* above piston *A* and that below, *L*, from an annular chamber formed between the pipe and the outer tube; this annular chamber may be connected to a leakage indicator (not shown) placed in the cabin of the vehicle. The operation of the device which has been described is as follows. For normal braking, the compressed fluid pressure is admitted to inlet *D* by a distributor valve (not shown), which may be controlled by a brake pedal. The thrust exerted by the fluid under pressure on the piston *A* in the chamber *K* is thus transmitted by piston *B* to the brake rigging. Upon release, the return spring brings the whole assembly back to its initial position. In this operation the chamber *L* remains in communication with atmosphere through *H*. In an emergency brake application a second distributor valve (not shown in the drawing), independent from that of the main brake, is used. The fluid pressure is admitted into the pipe *H*. The fluid under pressure passes into the chamber *L* and holds the piston *A* against the cover plate. This pressure then acts on the piston *B*, which bears as before on the thrust rod *E*. Any leakage occurring from either the main or the emergency brake, passes to a leakage indicator in the driver's cabin. The driver, being thus warned, can operate the other control system. It should be noted that as the two pistons *A* and *B* are of equal diameters, it follows that for a given pressure the main brake and the emergency brake exert the same force. It should also be noted that the simultaneous action of the main brake and the emergency brake does not result in an increased force on the thrust rod.—*March* 25, 1959.

HYDRAULICS

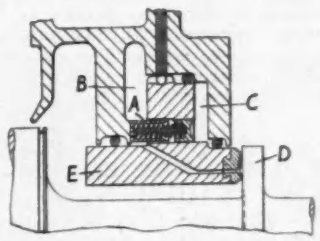
810,999. July 26, 1957.—LEAK DETECTOR FOR A PIPE, The Sperry Gyroscope Company, Ltd., Great West Road, Brentford, Middlesex. (*Inventor: Arthur Philip Glenny.*)

According to this invention, a detector for indicating a leak in a pipe carrying pressure fluid comprises a sleeve surrounding and sealed at each end around the pipe, or around a fitting to which the pipe is secured, to leave a sealed space between the pipe and the sleeve. A part of the sleeve is of flexible material which is distensible by pressure in the sealed space. An electrical conductor wound around this flexible section will break if the distention exceeds a certain amount. Conveniently this conductor can be connected in a warning circuit arranged to give a visual indication if the circuit is broken. In order to avoid having the whole length of the sleeve wound with the conductor, the sleeve can be arranged to be distended at a selected place or places around which the conductor is wound. The invention may be carried into practice in different ways, and one embodiment is described by way of example with reference to a drawing in the specification.—*March* 25, 1959.

SEALS

811,299. April 25, 1956.—SHAFT SEALS, C. A. Parsons and Co., Ltd., Heaton Works, Newcastle upon Tyne, 6. (*Inventor: William Douglass Horsley.*)

This invention relates to seals for shafts which rotate in a fluid-tight enclosure and prevent leakage of gaseous fluid along a shaft where it emerges from the enclosure. Its object is to provide an improved thrust collar seal, in which the loading on the sealing face may be controlled and which may therefore be utilised to seal gaseous fluids over a much greater range of pressures than is possible with the conventional arrangement of this type of seal now in use. The drawing shows a form of thrust collar seal according to one form of the invention. When a gas-tight enclosure incorporating a seal is operating with gas at or slightly above atmospheric pressure, the cumulative effect of the forces in the direction of the shaft collar exerted by the spring plungers *A*, the gas pressure on the enclosure end of the ring and the pressure of the sealing oil in the inner oil chamber *B* may be utilised to overcome the friction forces resisting the axial movement of the seal ring *E* in the housing. The loading on the sealing face will be low and no opposing pressure need be applied. No pressure need therefore be supplied to the outer chamber *C*. As the gas pressure in the enclosure is increased the sealing oil pressure in the inner oil chamber *B* must be increased proportionally. The increase in the



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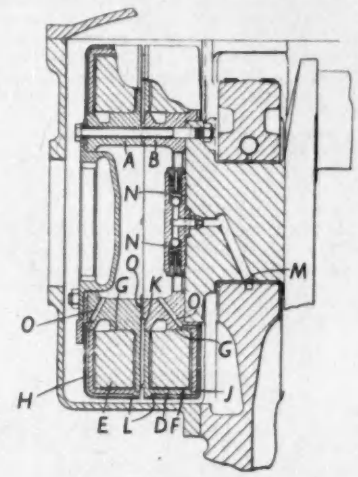
pressures of these two quantities will increase the pressure on the enclosure end of the seal ring towards the shaft collar *D*, thus increasing the load on the sealing face of the ring *E*. By supplying oil at suitable pressure to the outer oil chamber *C*, the additional forces in the direction of the shaft collar caused by the increase in gas pressure may be balanced and the load on the sealing face may be maintained constant over a very wide range of gas pressures. The pressure of oil in chamber *C* may be regulated manually or automatically.—*April* 2, 1959.

VIBRATION DAMPERS

811,350. June 14, 1957.—TORSIONAL VIBRATION DAMPERS, D. Napier and Son, Ltd., 211, Acton Vale, London, W.3. (*Inventors: George Hamilton Murray and Bryan Robert Boyle.*)

This invention relates to viscosity torsional vibration dampers having an inner member capable of at least limited rotary movement relative to the casing from which it is spaced to provide a viscous damping effect between the casing and the member when filled with a damping fluid of suitable viscosity. The operation of such dampers is dependent primarily on the viscosity of the damping fluid which is liable to be affected by changes in temperature thereby materially altering the damping characteristics. It is an object of the invention to reduce such undesirable alterations. In the example shown the damper is applied to one end of the crankshaft of an engine. The end of the crankshaft is carried in a normal fixed bearing and its outer end is secured to a casing assembly which comprises two ring members *A*, *B*, which have secured around their outer edges two corresponding annular cover plates *C*, *D*, thus forming two separate positively sealed annular fluid-tight coaxial chambers. Mounted within these chambers are inner inertia members *E*, *F* of annular form which substantially fill the chamber while providing a narrow clearance around its outer periphery and on each of its annular faces. Each of these inner members is located by a bearing surface *G*, in contact with the adjacent face of the inner wall



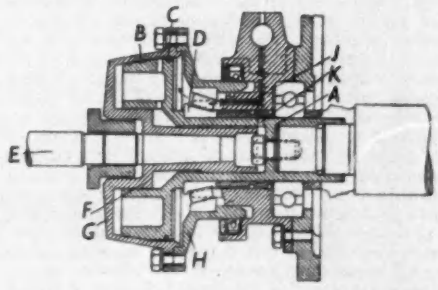
No. 811,350

of the respective chamber, and is free to rotate within the casing. The inner inertia members are of considerable mass and correspondingly high moment of inertia and the interior of the chambers is filled with a damping fluid of the desired viscosity such that torsional vibrations of the crankshaft are at least partially absorbed by the inertia of the annular members and the viscosity of the oil in the clearance spaces. The casing assembly is surrounded by a cooling jacket in the form of two annular half jackets *H*, *J*, which are spaced slightly from the outer cover plates *C*, *D* of the casing. A cooling passage *K* is also provided between the two annular chambers. The cooling space thus comprises three parallel paths, the two paths each including an annular section adjacent one of the end faces of the casing and a circumferential section surrounding part of the periphery of the casing. These three parallel cooling paths each have restricted outlet metering orifices *L* at the periphery of the cooling jacket. A stationary surrounding cover receives the cooling fluid from these orifices. Cooling oil is supplied to the paths from the fixed bearing of the crankshaft via a pick-up ring *M*. This ring communicates through a bore with a pair of centrifugally acting pressure relief valves *N*. Each valve comprises a chamber containing a ball offset from the axis of the crankshaft and spring-loaded away from a fluid outlet. At the outer end of the chamber a valve seating is formed on which the ball rests when the speed of rotation rises sufficiently to overcome the force of the spring. Thus at relatively high speeds the ball valves shut off the supply of cooling oil. Similarly at relatively low speeds the balls are urged by the springs towards the rotary axis and close the fluid inlets to the valve chambers. The outlets of the pressure relief valves *N* are connected to the interior of the casing within the two annular chambers, and from this cavity the cooling oil is distributed through a number of passages *O*, into the three cooling paths.—*April* 2, 1959.

MARINE ENGINEERING

811,395. February 4, 1957.—MARINE REVERSE GEAR MECHANISM, Archibald Malcolm Gilchrist Peace, Lake Cottage, Belton, Suffolk, and Albatross Marine, Ltd., St. Olaves, Norfolk.

The accompanying diagrammatic drawing illustrates one embodiment of the invention in which a



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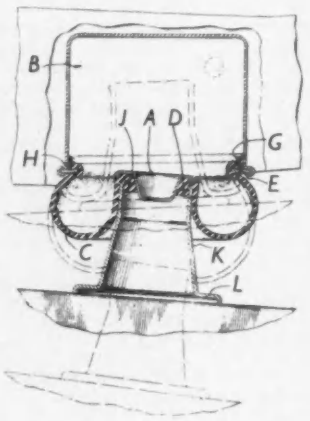
reverse gear mechanism is in the direct drive position. The driving shaft is bolted and keyed to a transmission member *A* with a conical drum *B* having a frictional surface and a ring seal *C*. The member *A* also carries a tapered roller bearing race *D*. A driven shaft *E* carries the propeller and a second transmission member *F*, which is provided with a conical drum *G* adapted to enter into engagement with the clutch *B*. The drum *G* is connected to a wheel *H* which carries the outer bearing race. In operation when the boat is to be driven forward the engine shaft is rotated in a clockwise direction and transmits motion through the members *A* and *B*, the clutch members *G* and *H* to the propeller shaft. Oil supplied via channels *J* enters the space between members *B* and *H* and forces the clutch surfaces into engagement. For reverse drive a valve, not shown, is operated to cut off the supply of oil along channel *J* and to allow it to flow via channel *K* into the space between members *A* and *F* and thence to the space between members *B* and *G*. This disengages the clutch surfaces and brings the bearing races together into heavy frictional contact with the rollers. The rollers being prevented from circumferential displacement, the clockwise motion of the race *D* on the member *A* now rotates the rollers in an anti-clockwise direction and they in turn rotate the outer race and so through members *H*, *G*, *F*, the propeller shaft in an anti-clockwise direction.—*April* 2, 1959.

VEHICLES

811,546. March 20, 1957.—VEHICLE SUSPENSION, General Motors Corporation, Grand Boulevard in the City of Detroit, State of Michigan, United States of America (Assignees of Robert Schilling, Kai H. Hansen, Philip C. Bowser and Richard E. Denzer).

This invention relates to suspensions comprising an air spring between sprung and unsprung portions of a vehicle. In the assembly shown in the drawing, a pivoted swing arm carries a wheel (not shown) and supports a frame member of the vehicle by an air spring. The air spring comprises a piston *A* secured to the arm, a reservoir member *B* secured to the frame, and a flexible member *C* between the piston and reservoir. The reservoir is a cylindrical tank having an open end and a connection to a source of air under pressure. The piston comprises an open ended tubular pedestal having a flat lower flange welded to the arm. The open upper end of the pedestal has its edge inwardly turned and rounded so that an inner bead ring on the flexible member can be snap engaged with the pedestal. A flanged cup element *D* closes the pedestal end and is secured over the bead ring to connect the flexible member to



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the piston. The flexible member also has an outer bead ring which is snap engaged over the inturned rounded edge of a ring *E* crimped to the open end of the tank. Air pressure within the tank is used to maintain the seal on the outer bead ring which has a flexible tapered lip. The bead rings contain metal rings *H* and *J*, which form anchorages for nylon cords (not shown) which reinforce the flexible member of rubber or other elastic material. Operation of the spring is marked by up and down movement of the piston, pedestal and arm, the upward movement being resisted by the increasing pressure of the air within the reservoir. In the drawing, dot-and-dash lines are employed to indicate upper and lower positions of the parts, and solid lines to indicate the positions under static load. During compression of the spring and upward movement of the piston, the flexible member is gradually laid in contact with the tapered wall *K* of the piston progressively to increase the effective piston diameter, so that the spring becomes stiffer. During downward movement, the effective piston diameter decreases as the flexible member is pulled out of contact with the tapered wall.—*April* 8, 1959.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

SLOTTED GRUB SCREWS

No. 768 : 1958. Price 4s. 6d. This standard, previously known as "Grub Screws," has been revised and published under the title "Slotted Grub Screws." It includes requirements for screws with UNC and UNF threads, as well as for screws with B.S.W., B.S.F. or B.A. threads ; but hexagon socket set screws are omitted as these fasteners are now dealt with in B.S. 2470.

The opportunity has been taken to include a number of general requirements in accordance with recent British Standards for screwed fasteners. Since the standard now provides for grub screws with Unified threads, every effort has been made to ensure that the dimensions and standard types of points do not conflict with those specified in the equivalent American standard. To assist designers in their choice of size, standard lengths of steel and brass grub screws are specified in an appendix.

METHODS OF TESTING VULCANISED RUBBER

No. 903 : Part A12 : 1958. Method for the determination of rubber-to-fabric adhesion (ply separation). Price 5s. Following its policy of revising B.S.903 : 1950 "Methods of Testing Vulcanised Rubber," the institution has now issued Part A12, and the main difference between this publication and Part 31 of the 1950 edition is in its layout and the incorporation of the appropriate metric equivalents.

The new part specifies the machine method and the dead load method, both for the determination of adhesion, and a proof test. Each method is accompanied by details of the test pieces, apparatus, temperature and report.

PVC-INSULATED CABLES FOR POWER SWITCHGEAR WIRING

No. 1231 : 1958. Price 5s. In this revision of the standard issued in 1945 the range of cables has been extended to deal with all voltages normally encountered in the small wiring of power switchgear.

Of the four types of cable specified, Type A is intended for supervisory circuits and similar purposes and Type B, which is suitable for working voltages up to 250V to earth, corresponds to the type specified in the 1945 edition. Cables in Types C and D are suitable for higher voltages, and some may be of use for such purposes as internal connections in rectifier equipment, and in motor starter and controllers.

The new publication provides a complete series of tests similar to those required by B.S. 2004 for the PVC-insulated cables used in the wiring of buildings.

HIGHER TENSILE STEEL HOOKS OF THE "C" OR LIVERPOOL TYPE

No. 3033 : 1958. Price 7s. 6d. This new publication specifies requirements for eye hooks for use with chain pendant or with shackle pins ; and for shank hooks. It also deals with the same two types of hook fitted with a gravity safety catch. As the hooks are designed for heavy duty shipping purposes and for general engineering purposes and building operations, two appropriate ranges of safe working loads are provided.

The standard specifies requirements for : material, workmanship, heat treatment, tests on both material and finished product, inspection, certification and marking. Four full-page diagram of hooks are "keyed" to data in associated tests.

DIMENSIONS OF BALL BEARINGS AND PARALLEL ROLLER BEARINGS

No. 292 : 1958. Price 12s. 6d.—This revised publication relates to those features which control the interchangeability of bearings as units ; it does not deal with their internal dimensions or detailed design. Dimensions are specified for single-row, angular contact and double-row journal bearings ; for rigid, parallel-roller, journal bearings ; for snap-ring type ball journal bearings ; for magneto bearings, and for single-thrust bearings with flat seatings and with spherical seating rings. Inch and metric sizes are provided up to 30in and 400mm minimum bore, respectively, though not as equivalents.

The tolerances on bearing external dimensions, diametral clearance, and permissible errors due to wobble and eccentricity are specified, as are fillets and shoulder heights for metric journal bearings. A standard nomenclature for the component parts of bearings is included, with the British Standard reference symbols for each type and size of bearing.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Thurs., May 28.—BRIGHTON, HOVE AND DISTRICT BRANCH : New Imperial Hotel, First Avenue, Hove, Branch Annual General Meeting ; "Lighting and Colour," Messrs. Chappell and Matthews, 6.45 p.m. ★ SOUTH LONDON BRANCH : Greyhound Hotel, High Street, Croydon, Branch Annual General Meeting and Lecturettes, 7.15 p.m.

Sat., May 30.—WOLVERHAMPTON AND DISTRICT BRANCH : Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, Branch Annual General Meeting, 7 p.m.

CHEMICAL SOCIETY

Thurs., June 4—Burlington House, Piccadilly, London, W.1. "Kinetics and Orientation of Some Epoxide Ring Opening Reactions," N. B. Chapman, N. S. Isaacs and R. E. Parker ; "Aromatic Reactivity : Part III, Cleavage of Substituted Phenyltrimethylsilanes by Sulphuric Acid in Acetic Acid-Water," F. B. Deans and C. Eaborn ; and "The Heats and Entropies of Ionisation of Some Aromatic and N-Hetero-aromatic Amines," J. J. Elliott and S. F. Mason, 7.30 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., May 27.—Grand Hotel, Charing Cross, Glasgow, C.3. "Economic Purchase of Coal for Small Plants," G. Armstrong, 10.30 a.m.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Thurs., May 28.—Room 127, City and Guilds College, Exhibition Road, London, S.W.7, "Uplift in Gravity Dams," Serge Leliavsky, 4 p.m.

INSTITUTE OF METALS

Thurs., May 28.—17, Belgrave Square, London, S.W.1. "The Atomic Mechanisms of Fracture," N. J. Petch, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 26.—Great George Street, Westminster, London, S.W.1, "The Cape Town Wemmershoek Water Scheme," S. S. Morris, 5.30 p.m.

Tues., June 9.—Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.

Wed., June 17.—Great George Street, Westminster, London, S.W.1, Conversazione, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, May 22, *to Wed., May* 27.—RADIO AND TELECOMMUNICATION SECTION : Earls Court, London, S.W.5, International Convention on Transistors and Associated Semiconductor Devices.

Mon. to Fri., June 15 *to* 19.—Summer Meeting at Harrogate.

INSTITUTION OF MECHANICAL ENGINEERS

Mon. to Fri., June 29 *to July* 3.—Summer Meeting in Switzerland.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., June 6.—NORTH MIDLANDS REGION : Ericsson Telephones, Ltd., Beeston, Nottingham, One-day Conference, "Communication of Ideas in Production—Its Importance and Improvements."

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., May 28.—11, Upper Belgrave Street, London, S.W.1, Annual General Meeting, 6 p.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., May 28.—SUMMER MEETING : Visit to Imperial Chemical Industries, Ltd., Tunstead Quarry, near Buxton, 1.45 p.m.

ROYAL STATISTICAL SOCIETY

Tues., May 26.—MEDICAL SECTION : London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, Annual General Meeting ; "The Value of Periodic Health Examinations," J. C. McDonald, 5.30 p.m.

Wed., May 27.—London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, "Optimum Experimental Designs," J. Kiefer, 5 p.m.

UNIVERSITY OF CAMBRIDGE

To-day, May 22, *to Fri., June* 19.—Engineering Laboratory, University of Cambridge, Trumpington Street, Cambridge. Exhibition to commemorate the Centenary of the death of Isambard Kingdom Brunel, 9 a.m. to 5 p.m. ; Sats., 9 a.m. to 12 noon.

WOMEN'S ENGINEERING SOCIETY

Wed., June 10.—"Hope House," 45, Great Peter Street, Westminster, London, S.W.1, Annual General Meeting, 7 p.m.

Advanced Engineering Courses

Techniques of Non-Destructive Testing. PHYSICS DEPARTMENT, BRUNEL COLLEGE OF TECHNOLOGY, Woodlands Avenue, Acton, London, W.3. Course of ten lectures, Wednesday evenings from 7 p.m. to 8.30 p.m., commencing October 7. Fee £1.

Advanced Work Measurement. INSTITUTE FOR ENGINEERING PRODUCTION, UNIVERSITY OF BIRMINGHAM, 16, Norfolk Road, Birmingham, 15. The course will deal with advanced aspects of work measurement with special emphasis on the way in which statistics may be used to assist in work measurement and in determining the accuracy and validity of measurements made. Various ways of improving work measurement will be discussed. The course will run from 9.30 a.m., Monday, May 25, until Friday, June 5. The inclusive charge for the two-week residential course is 60 guineas.

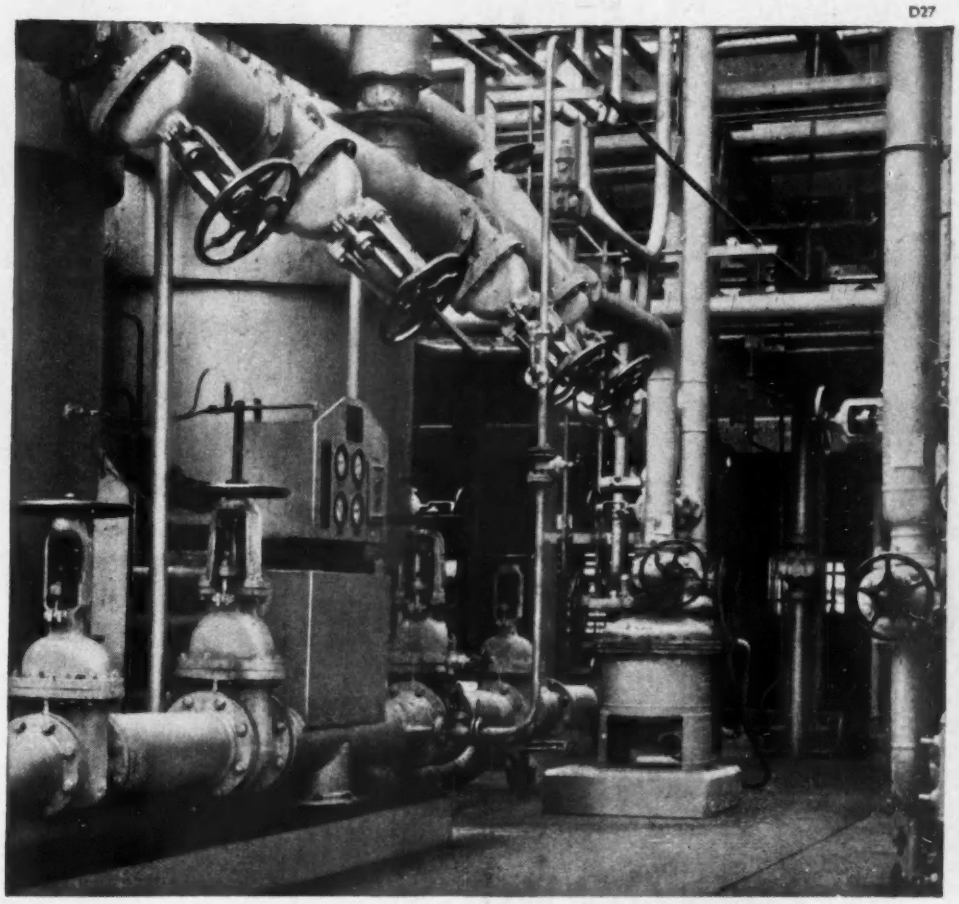
The Application of Work Study. INSTITUTE FOR ENGINEERING PRODUCTION, UNIVERSITY OF BIRMINGHAM, 16, Norfolk Road, Edgbaston, Birmingham, 15. The primary purpose of the course is to examine work study theory and research and its practical application as the direct approach to increasing industrial productive efficiency, by the more effective employment of existing equipment, materials and personnel. The course will be held from 9.30 a.m., Monday, June 8, until 3.30 p.m., Friday, June 19. The inclusive charge for the two-week residential course is 55 guineas.

Postgraduate Course in Nuclear Technology (Chemical). IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, South Kensington, London, S.W.7. The object of the course is to provide a general training in the chemical and metallurgical aspects of nuclear technology, interpreted in a wide sense. The course is intended for graduates in chemical engineering, chemistry and metallurgy and is also available to suitably qualified applicants from industry. It is full-time and of one year's duration, starting in October. Fee £64.

Once again, valves by Crane

D27

The new Olefine Plant — the second of its kind — has been built in the heart of Wilton Works for the Billingham Division of Imperial Chemical Industries Limited. Here important raw materials are manufactured for the other I.C.I. plants; and here working under arduous conditions (extremes of temperature) are many Crane valves. As on the first Olefine Plant, this new plant has Crane steel valves up to 16 inch. Here is proof once again of industry's reliance on Crane's dependability and performance, a reliance based on modern production methods, individual factory testing and high grade materials which go into every one of the Crane products. This plant was designed and installed by Kellogg International Corporation.



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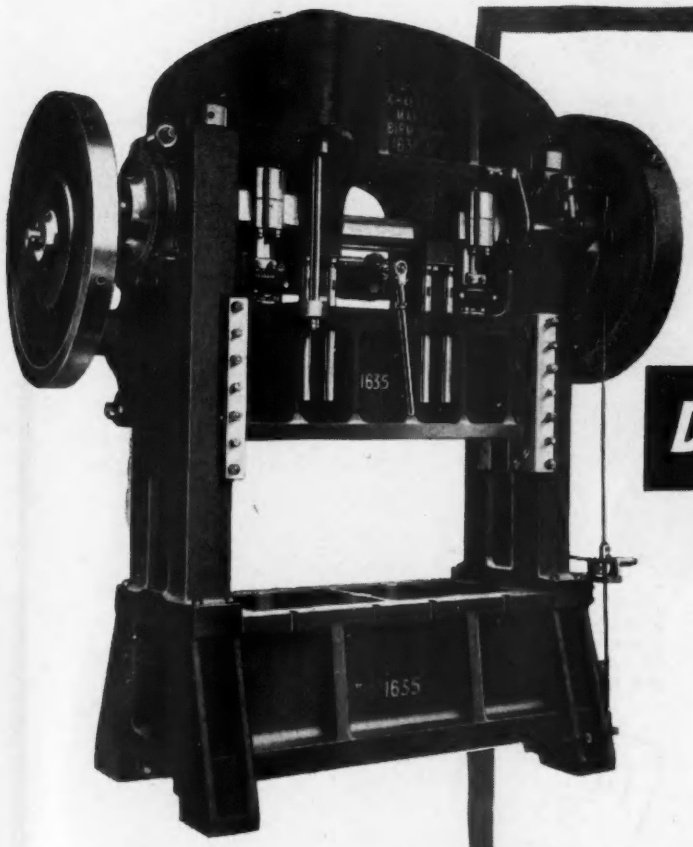

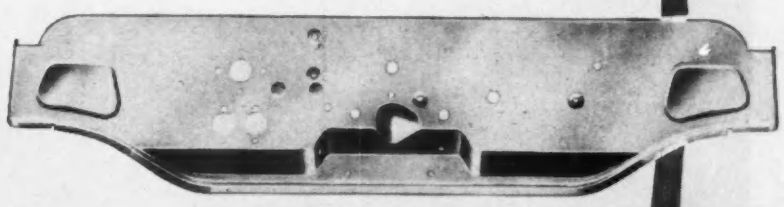

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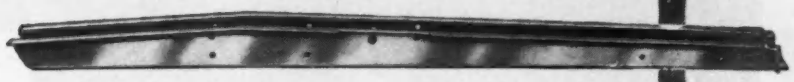

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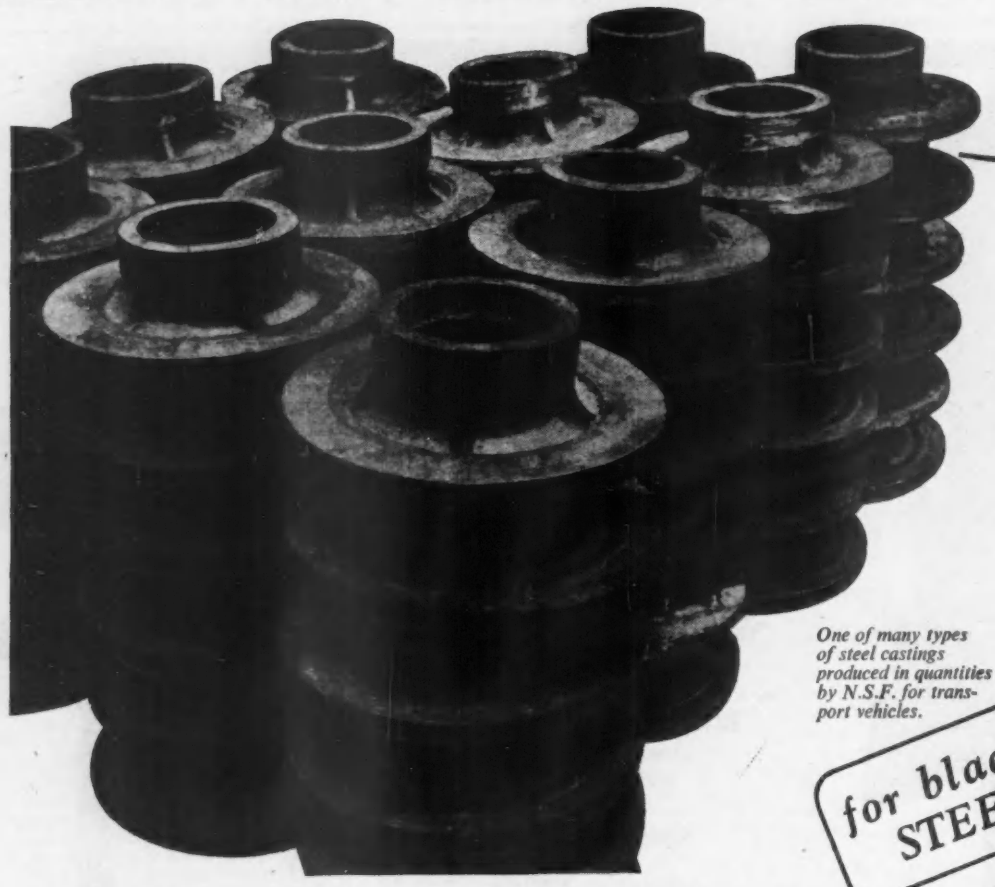

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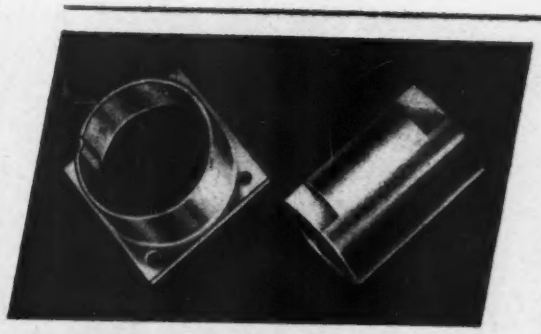

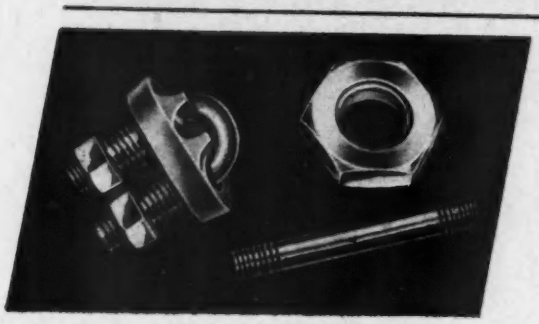

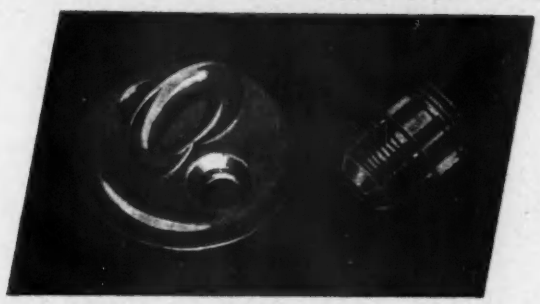

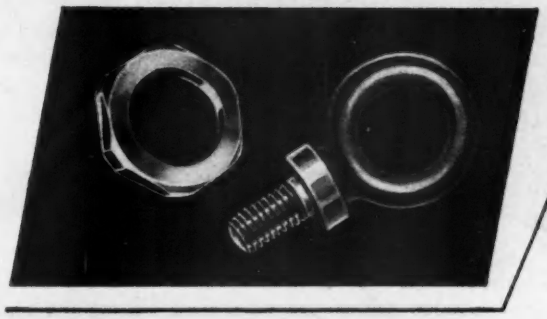

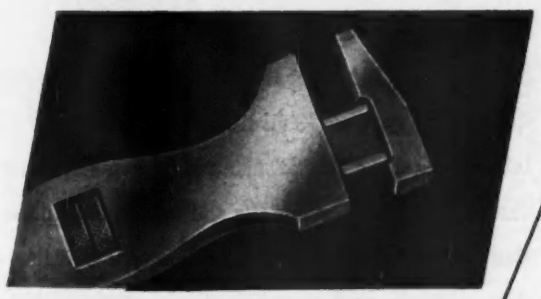

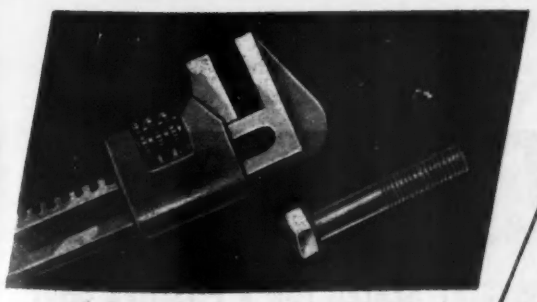

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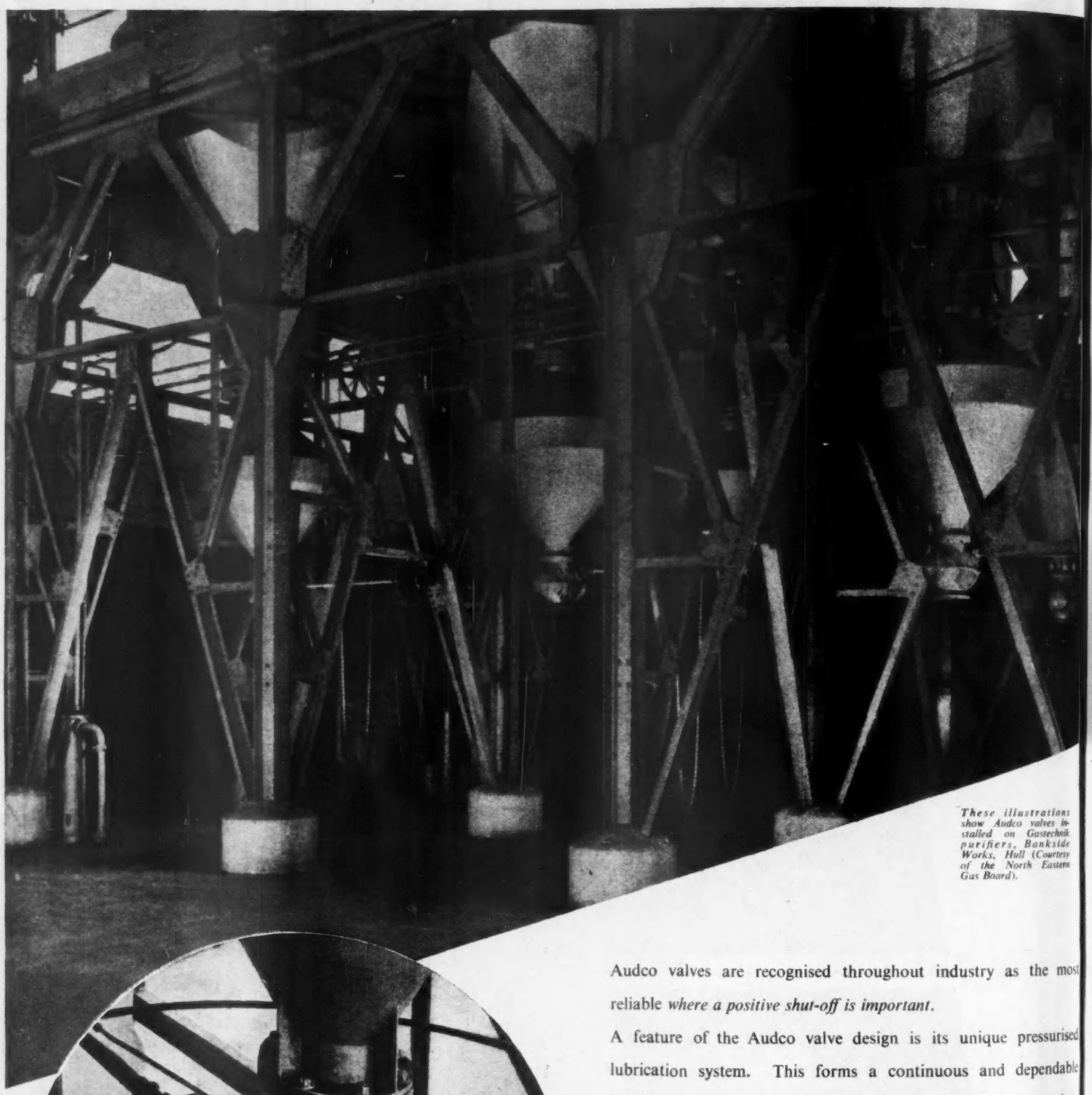
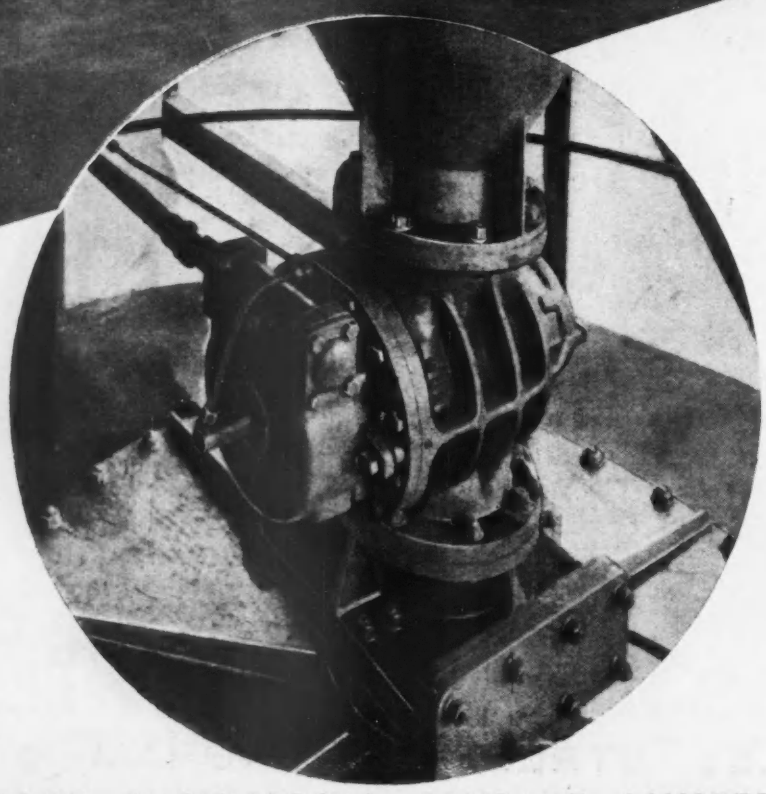


These illustrations show Audco valves installed on Gastechnik purifiers, Bankside Works, Hull (Courtesy of the North Eastern Gas Board).



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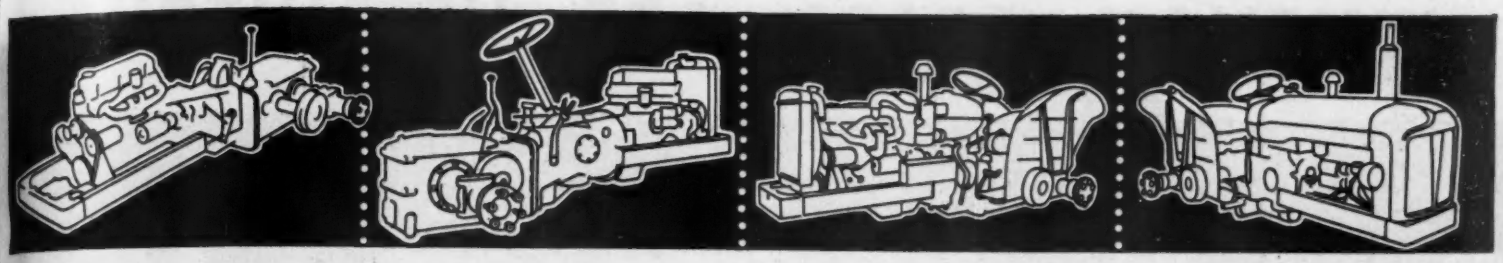

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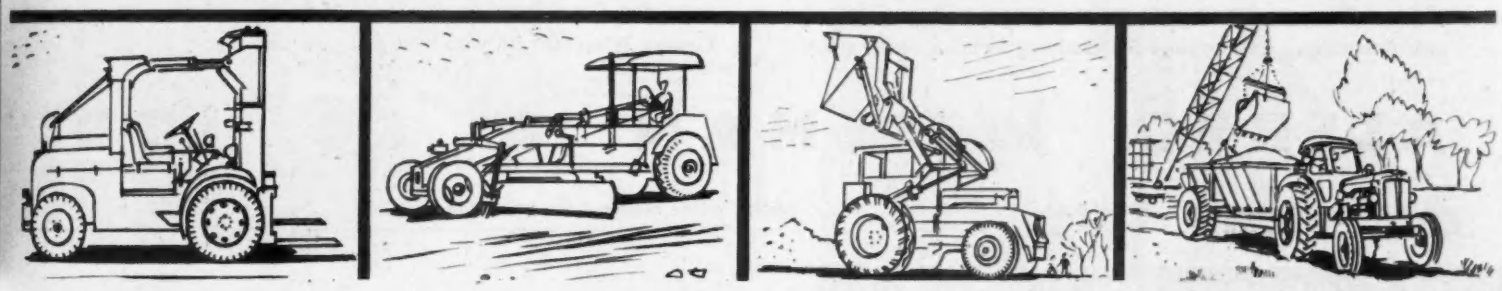

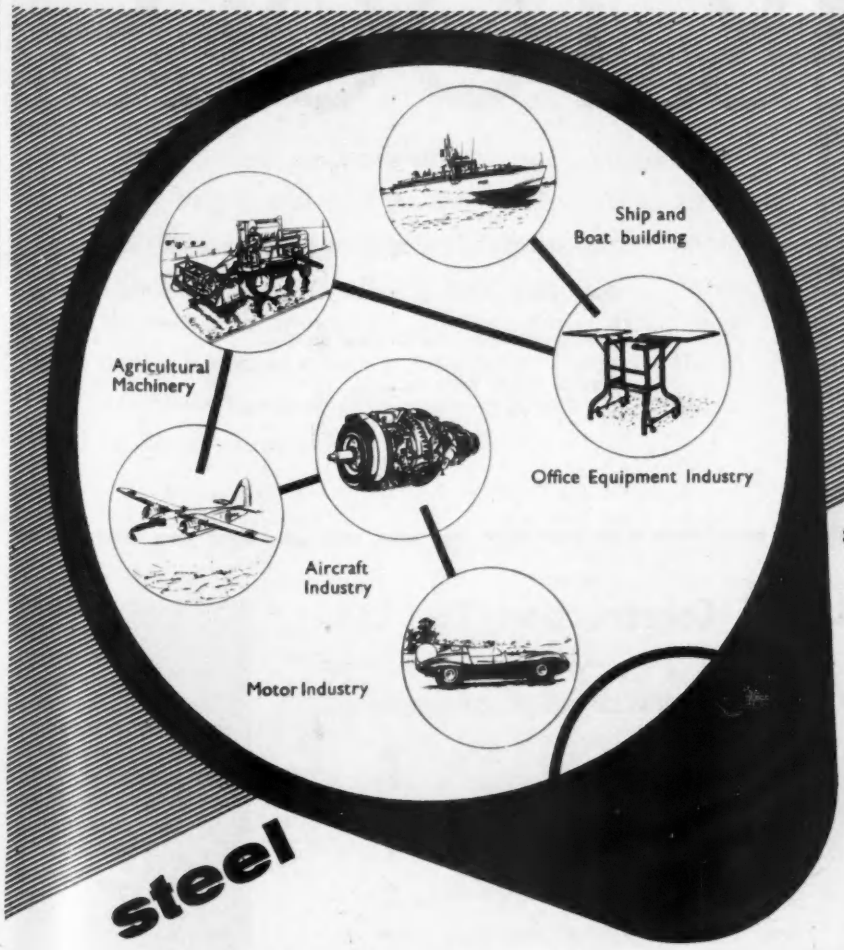

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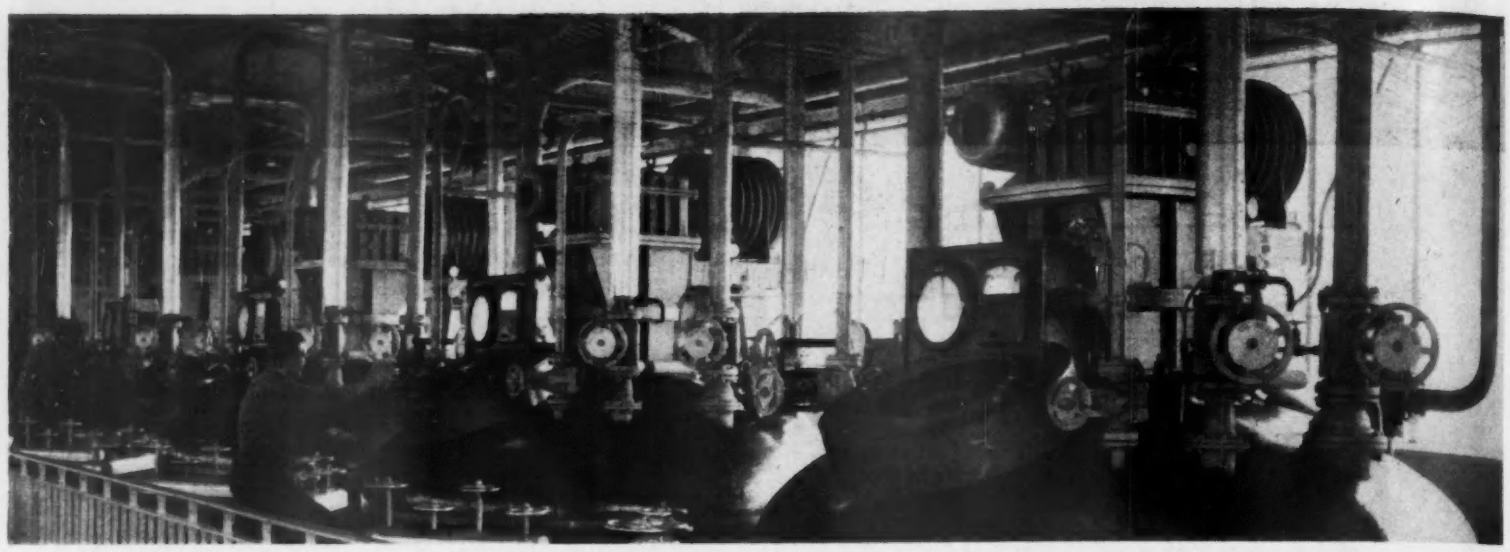

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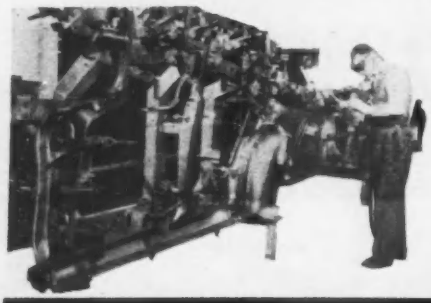

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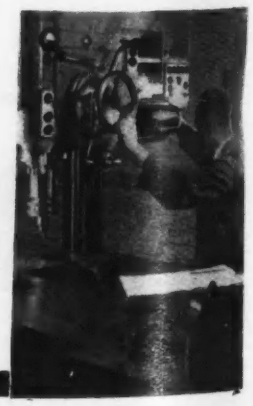

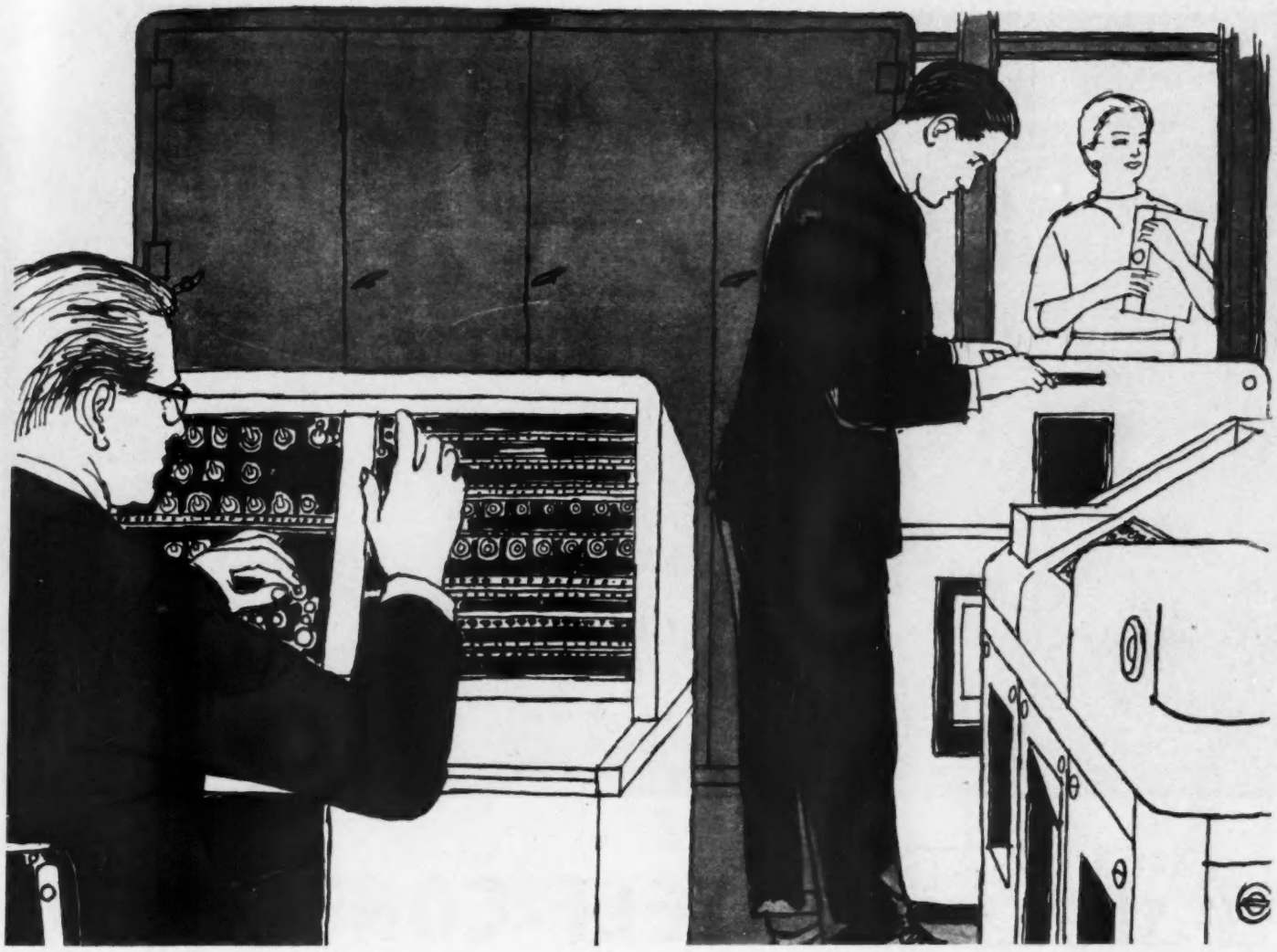

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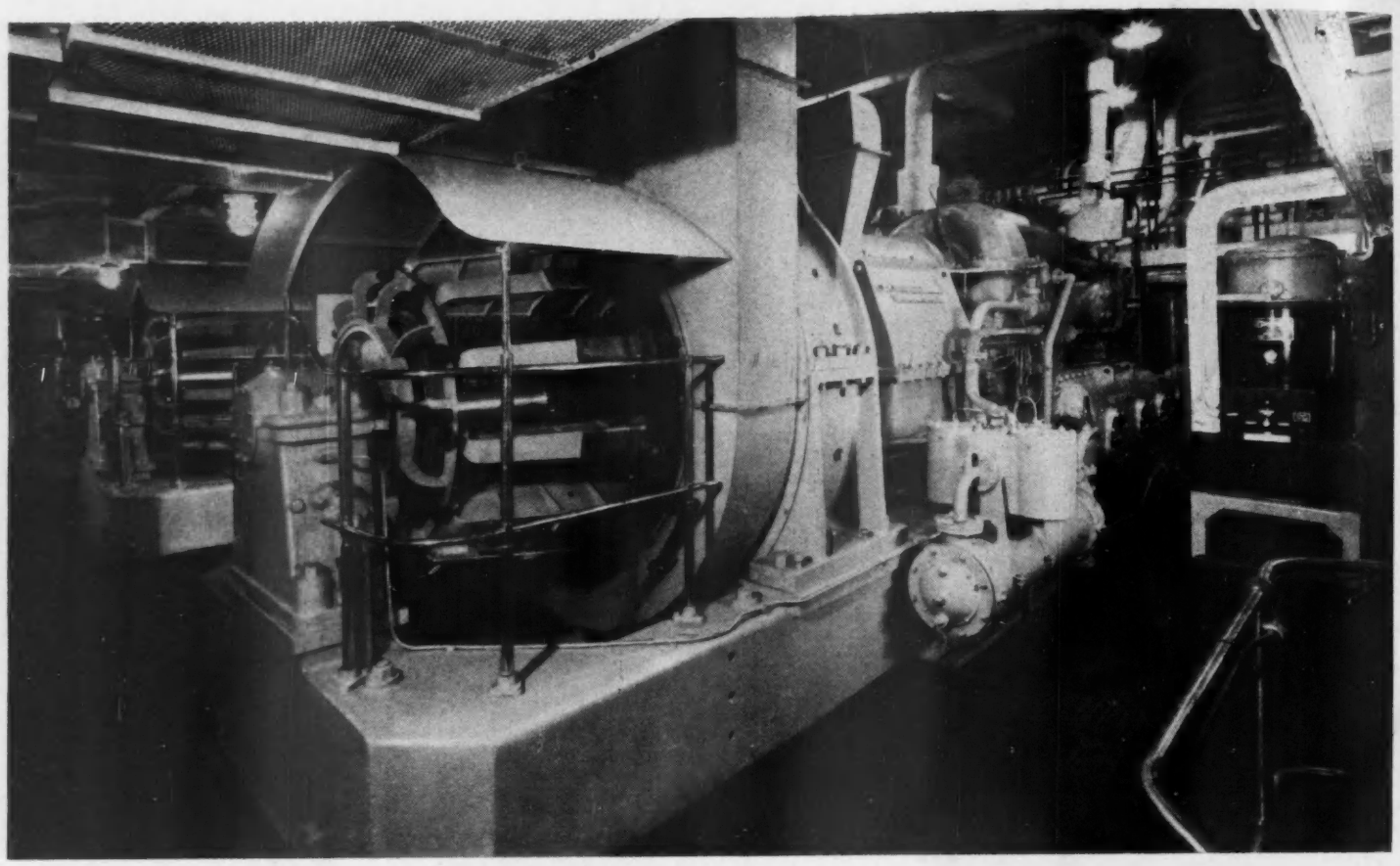

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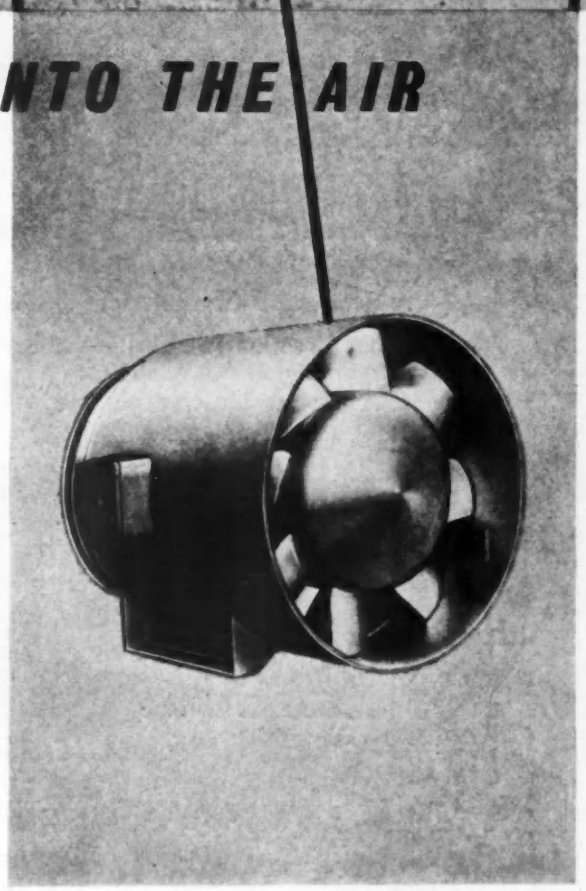

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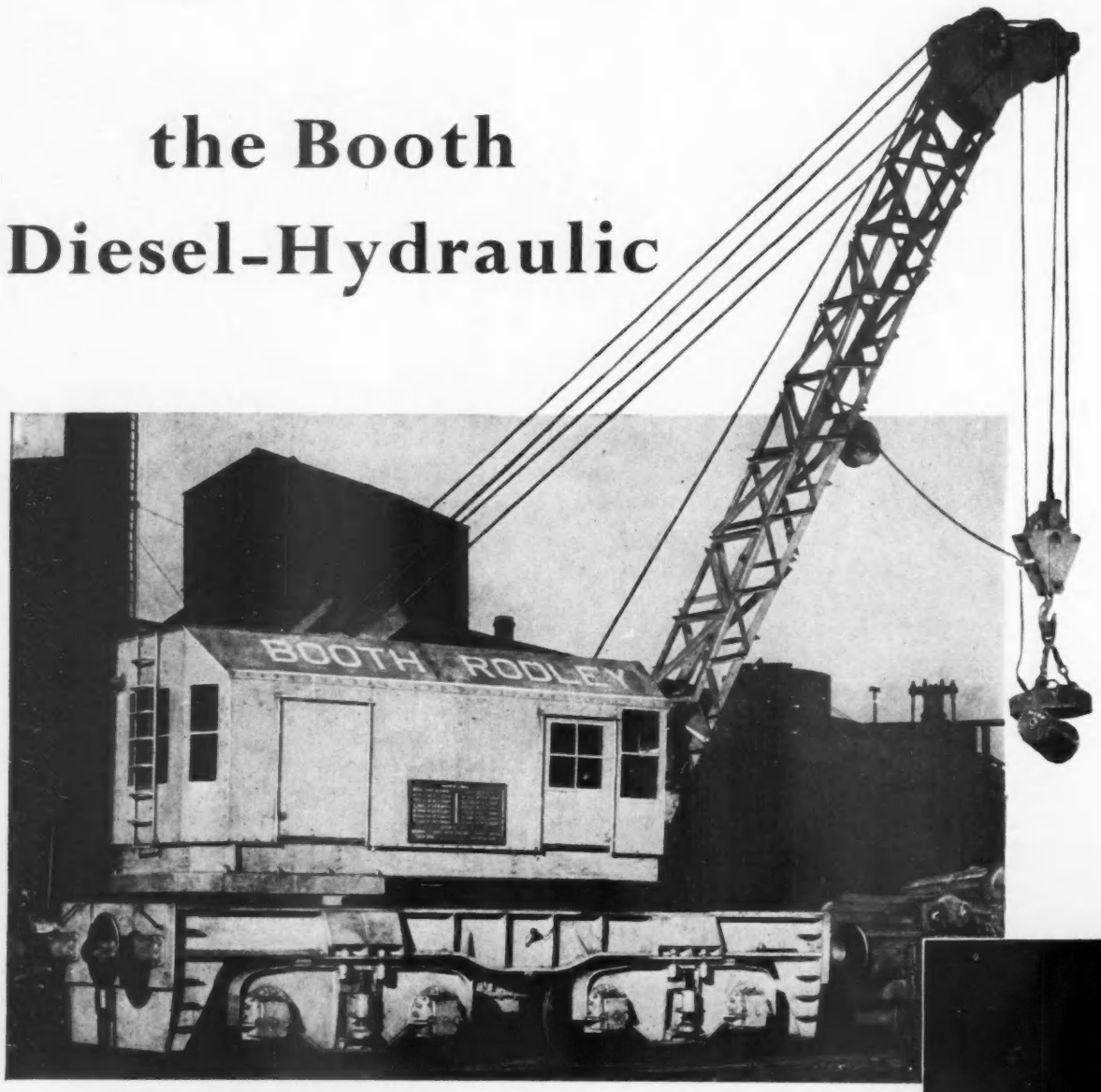

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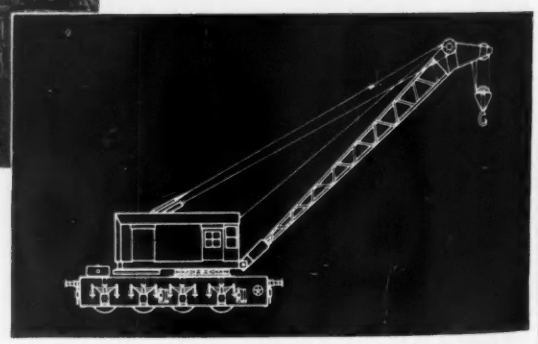

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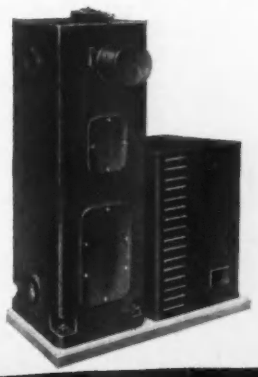

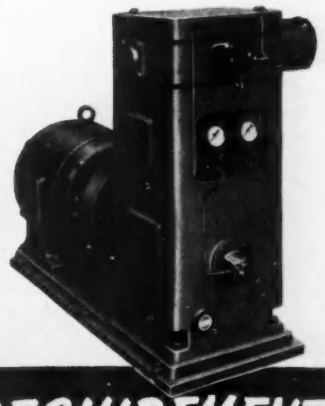

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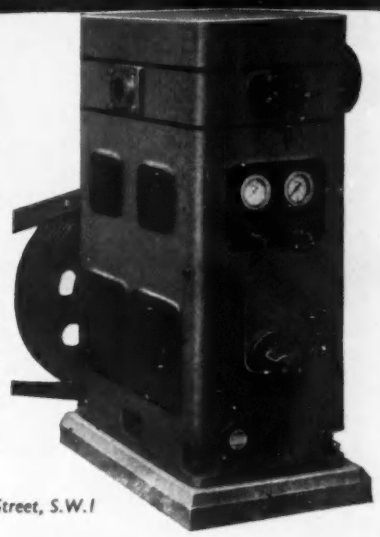

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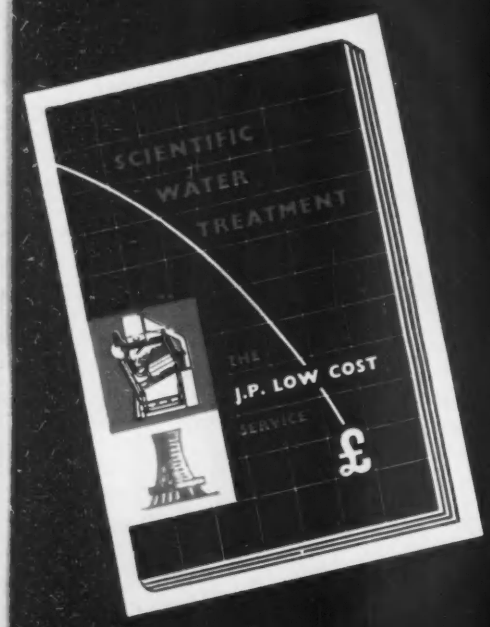

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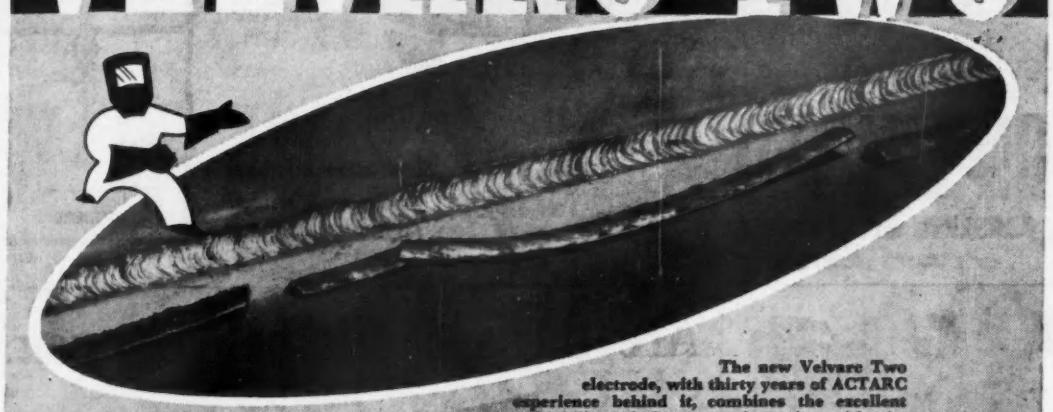

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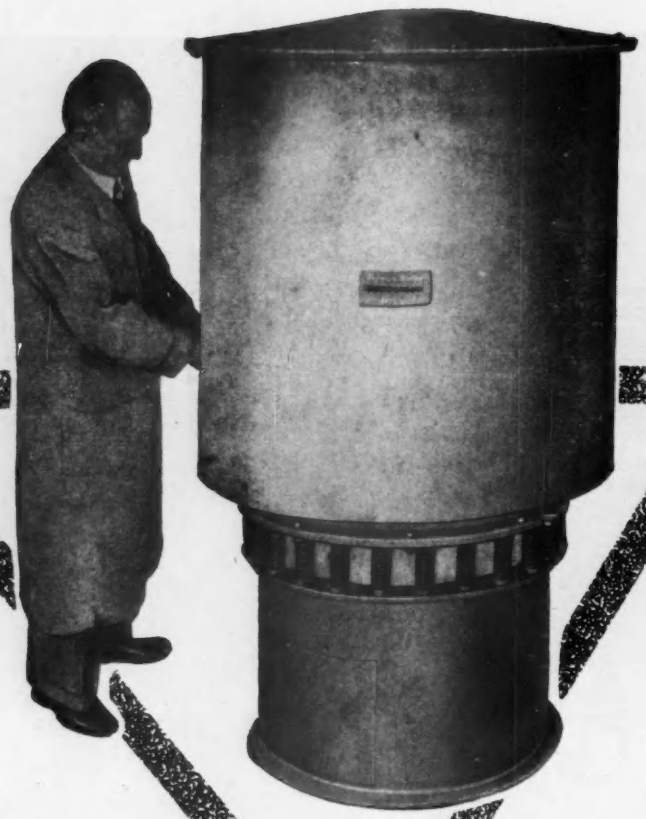

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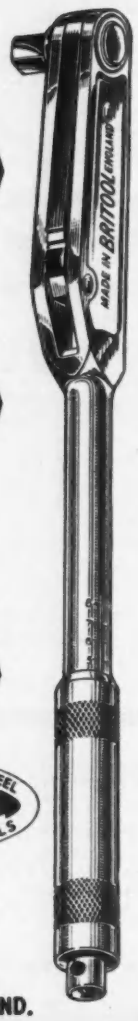

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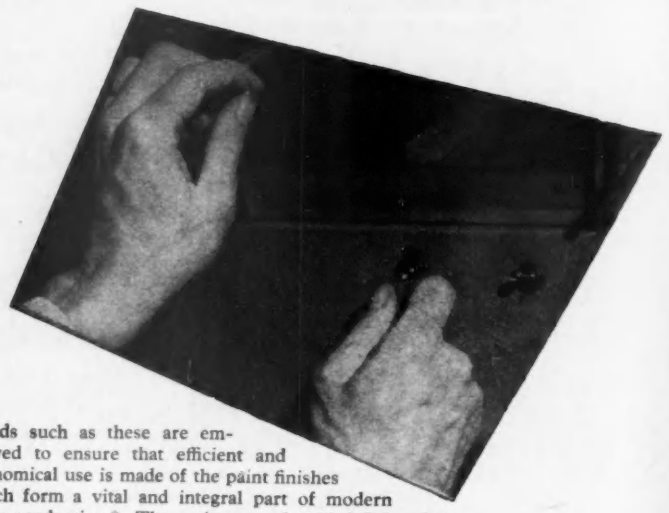

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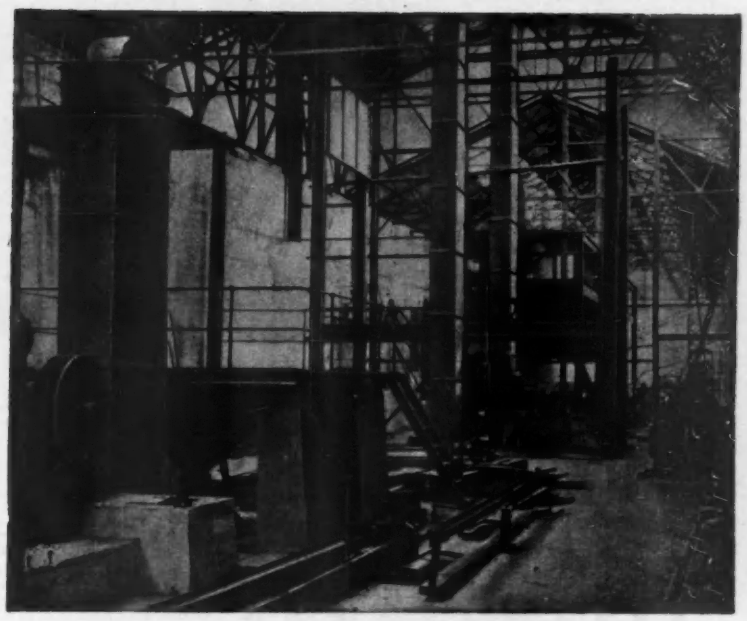

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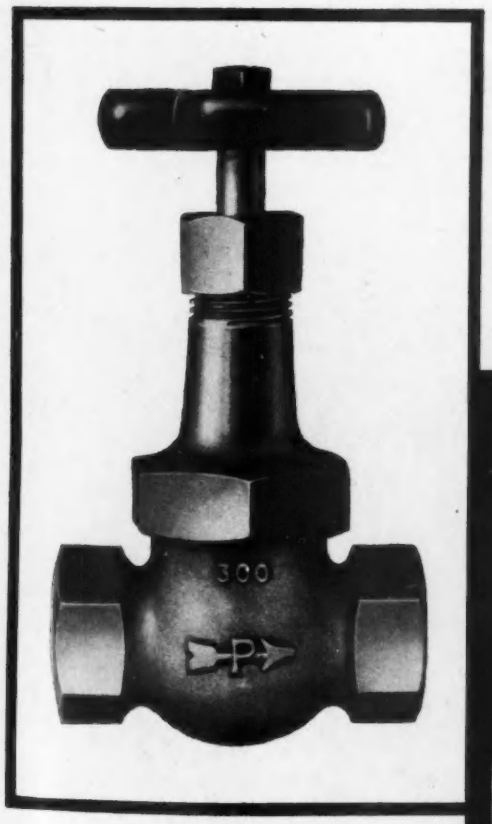

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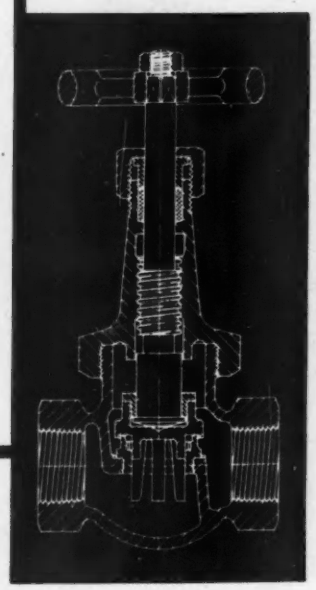

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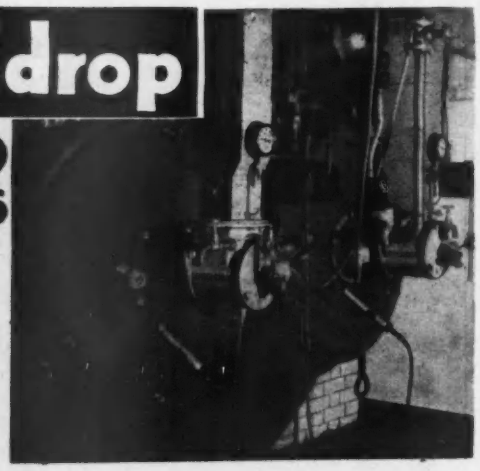

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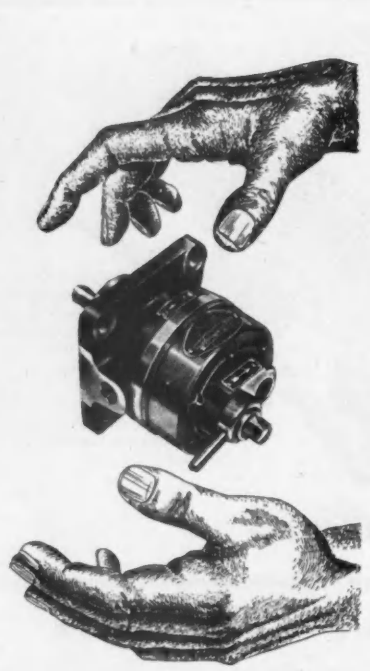

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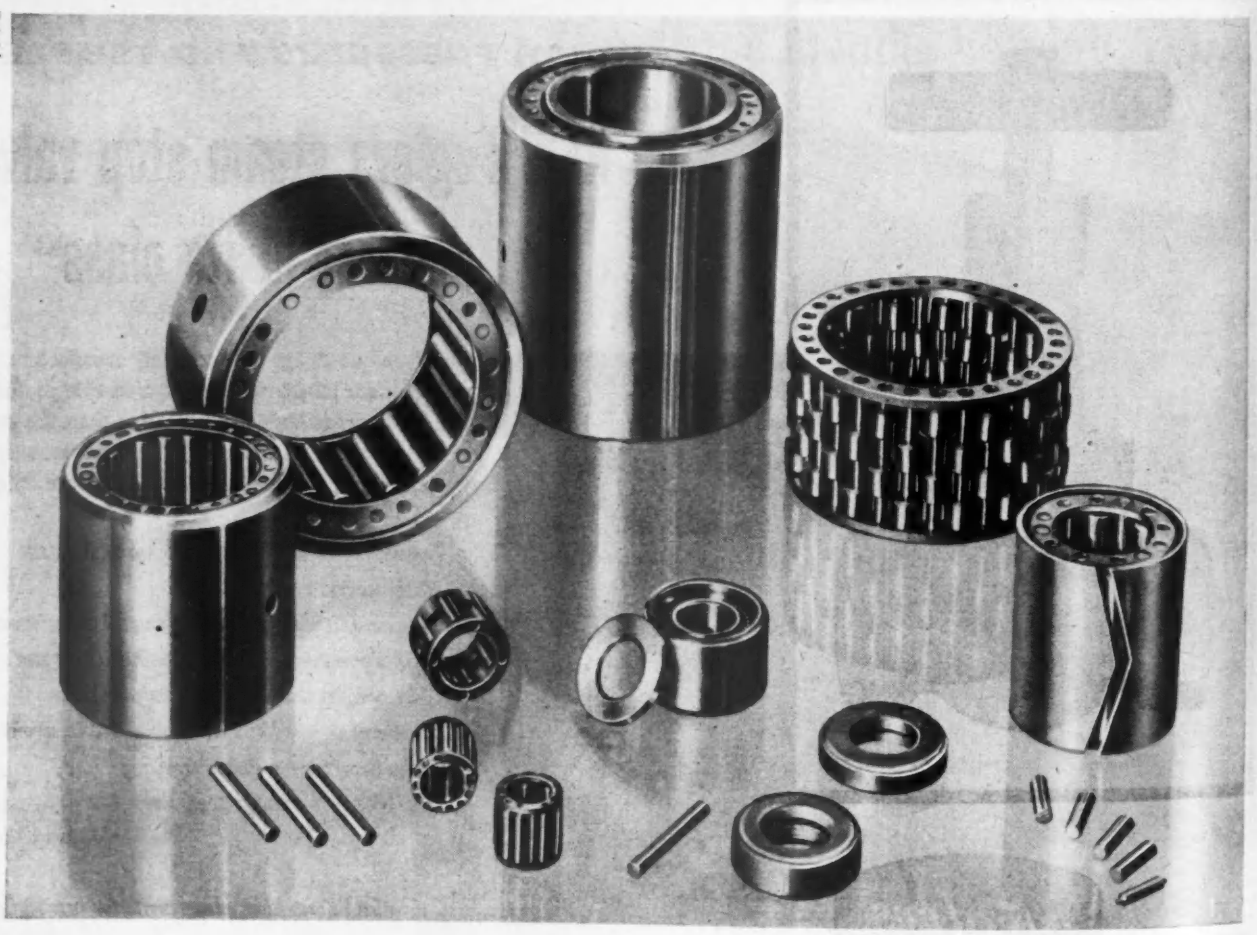

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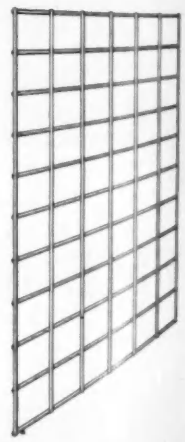

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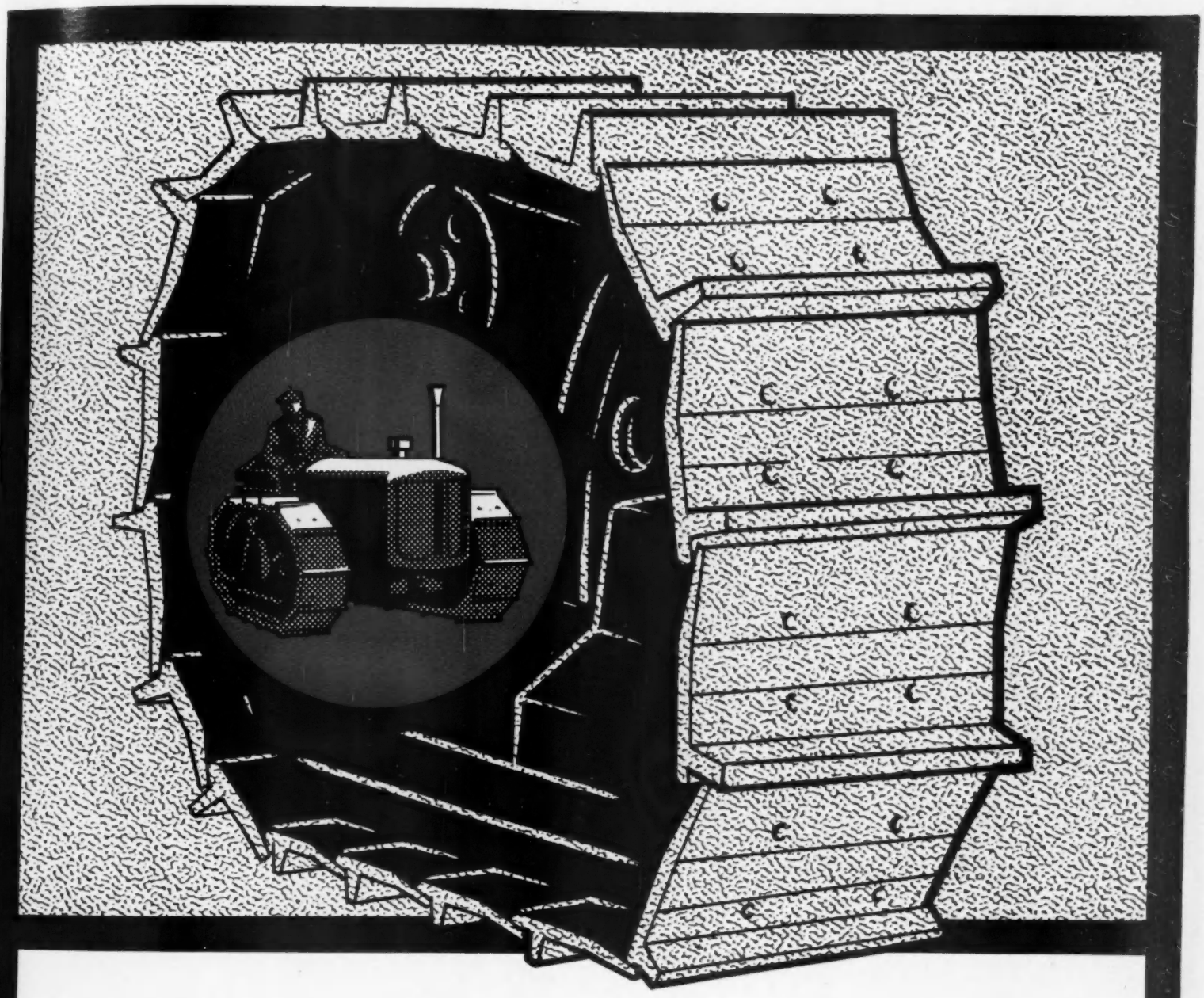

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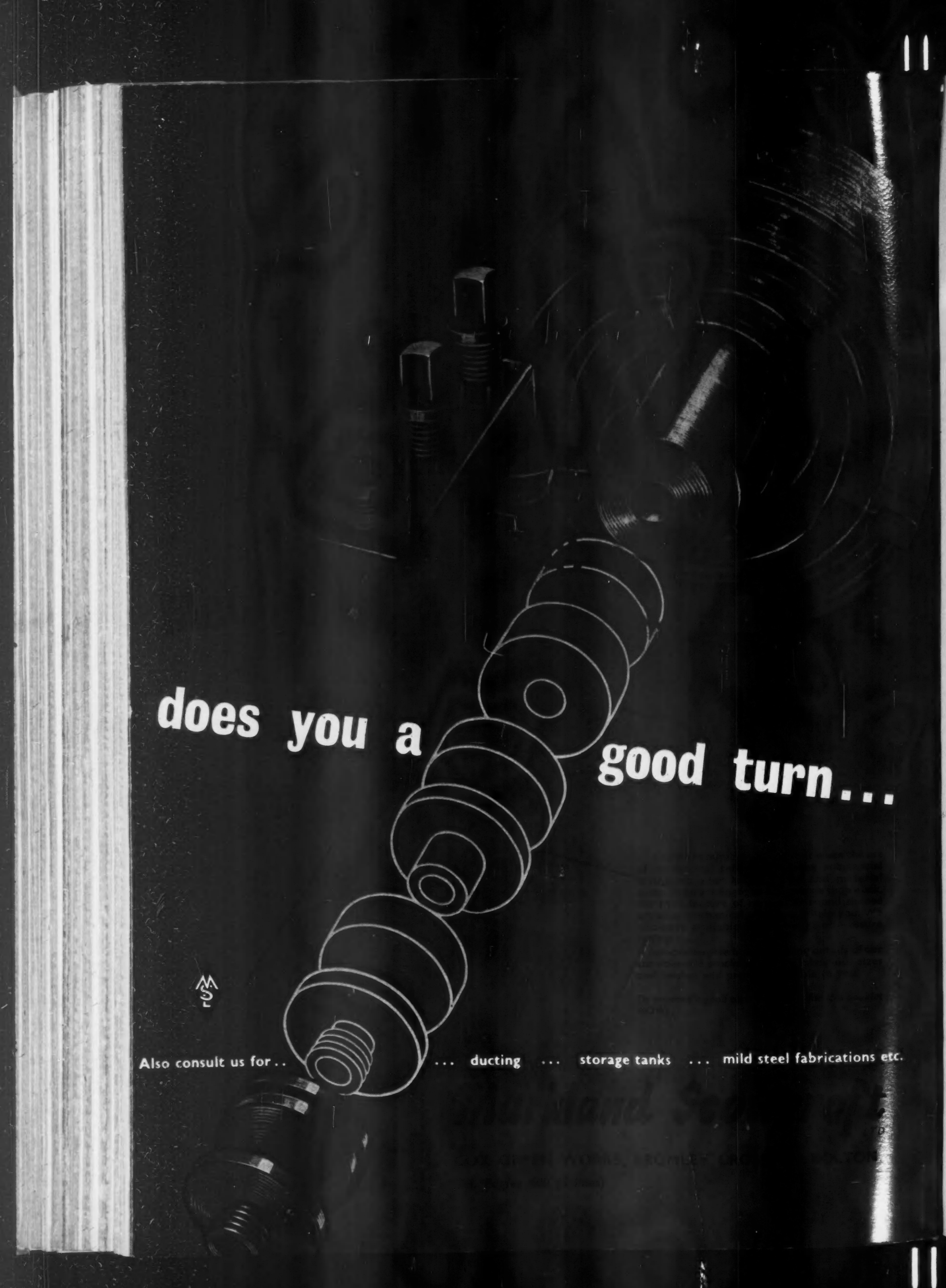
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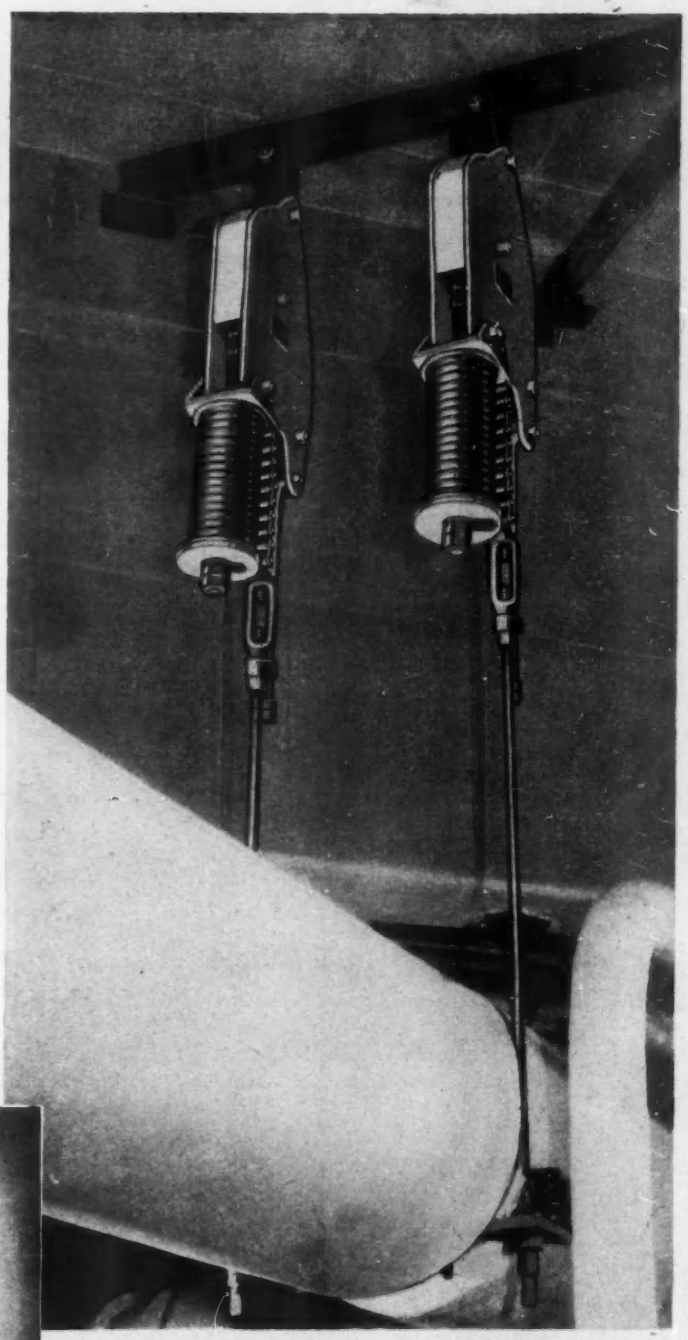
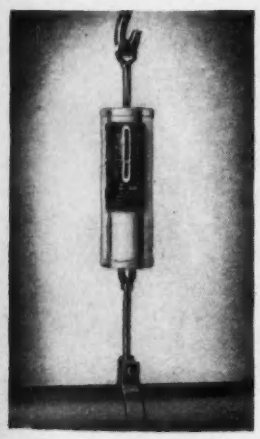


Ferrybridge " B " Power Station, Central Electricity Generating Board, Yorkshire Division. H.P. Steam pipes supplied and installed by Stewarts and Lloyds, Ltd.



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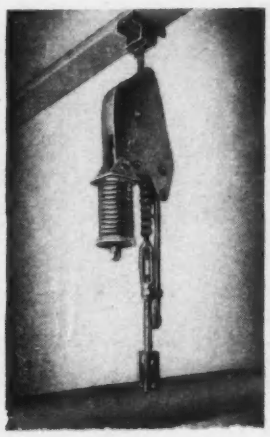
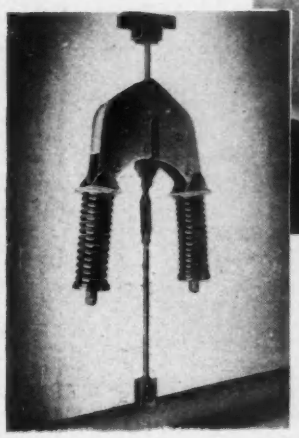


Conventional type " Con-Ten" Supports for loads of up to 2 tons with a total vertical movement up to 12″.



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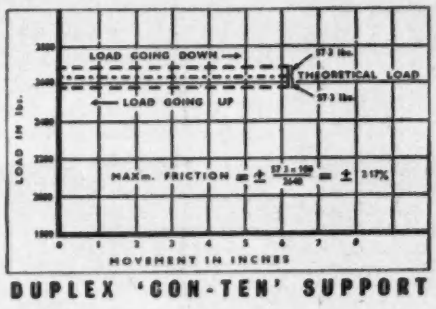

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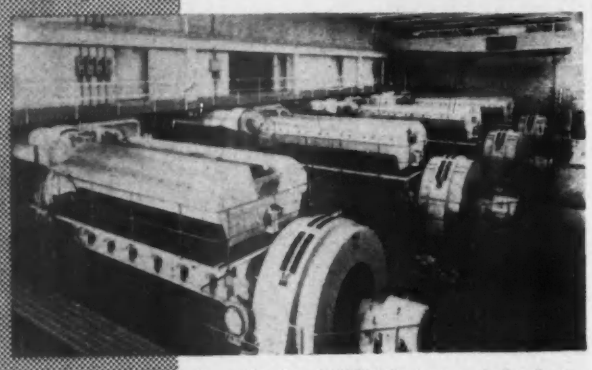

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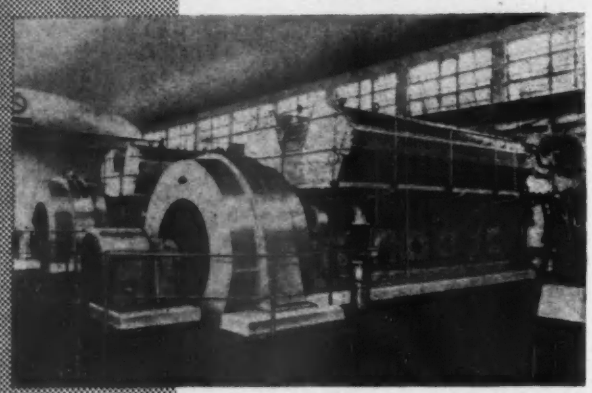

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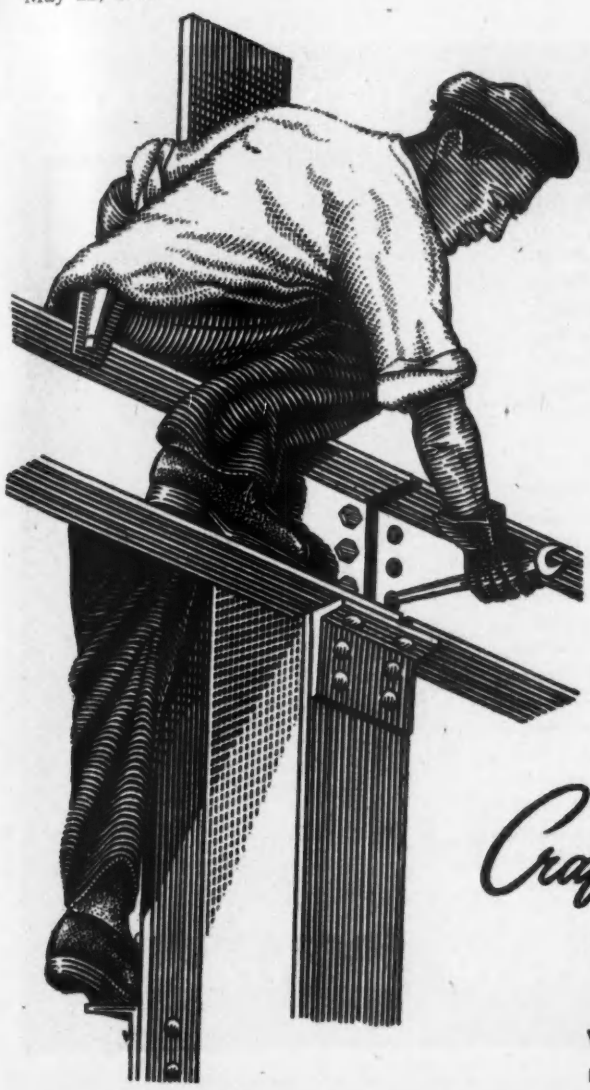

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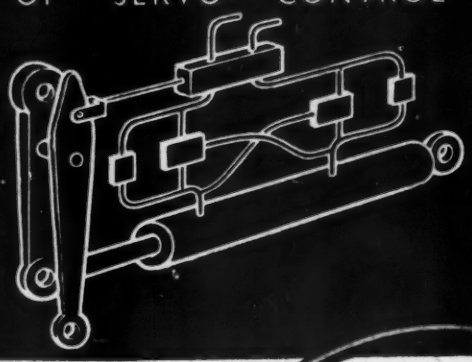

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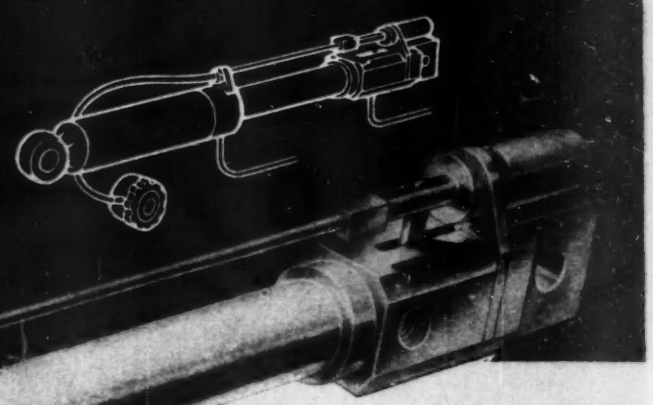

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Make checks in situ at different locations with varying problems, quickly and easily with this new Multimeter. Just plug-in the appropriate transducer, set the 6-position selector switch and read off pressure, tension, load, strain or displacement on the directly calibrated scale. In addition, recording or control can be carried out and the instrument is provided with an electrical output for this purpose.

SPECIFICATION

Energising supply : 5.0 v. ; Max. current 200 mA ; Frequency 1 Kc/s ;
Electrical output ± 0.15 mA full scale into 1,500 ohms load ;
Mains supply 200-250 v. 50 c/s; Dimensions 15" x 9" x 6" deep; Weight (approx.) 20 lb.

Why not write us for full details of the new Multimeter and our new type transducers? All are specially designed to simplify testing.

A new model is under development for use with opaque fluids, and special designs can be made to meet specific requirements.

Note these features

- *Simple design ensures complete reliability.*
- *Extreme sensitivity at all pressures.*
- *Units readily adaptable to existing installations.*
- *May be mounted in any plane.*
- *Comparative flow gauged by speed of revolving rotor.*

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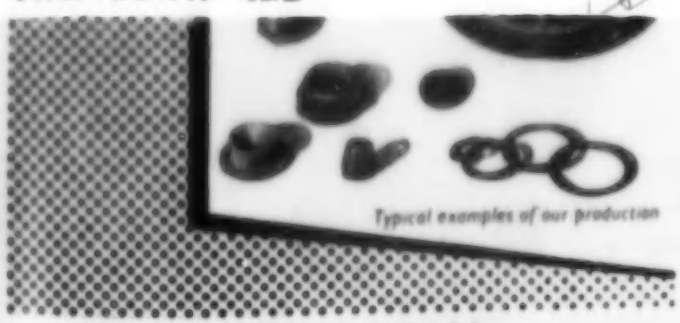

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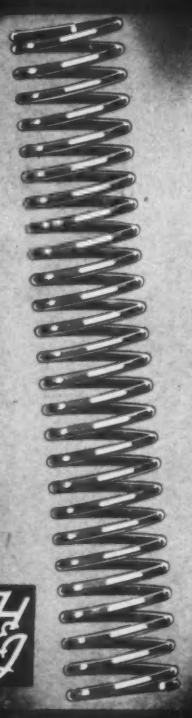

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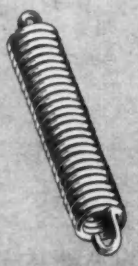

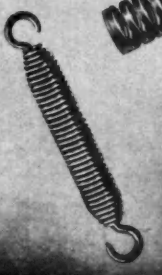

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SPECIFICATION

Energising supply: 5.0 v.; Max. current 200 mA; Frequency 1 Kc/s;
Electrical output ±0.15 mA full scale into 1,500 ohms load;
Mains supply 200-250 v. 50 c/s; Dimensions 15" x 9" x 6" deep; Weight (approx.) 20 lb.

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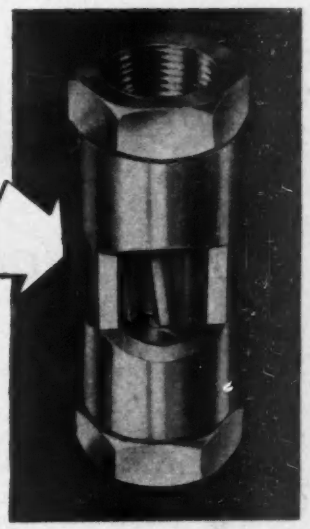
See the flow with the 'Telicator'



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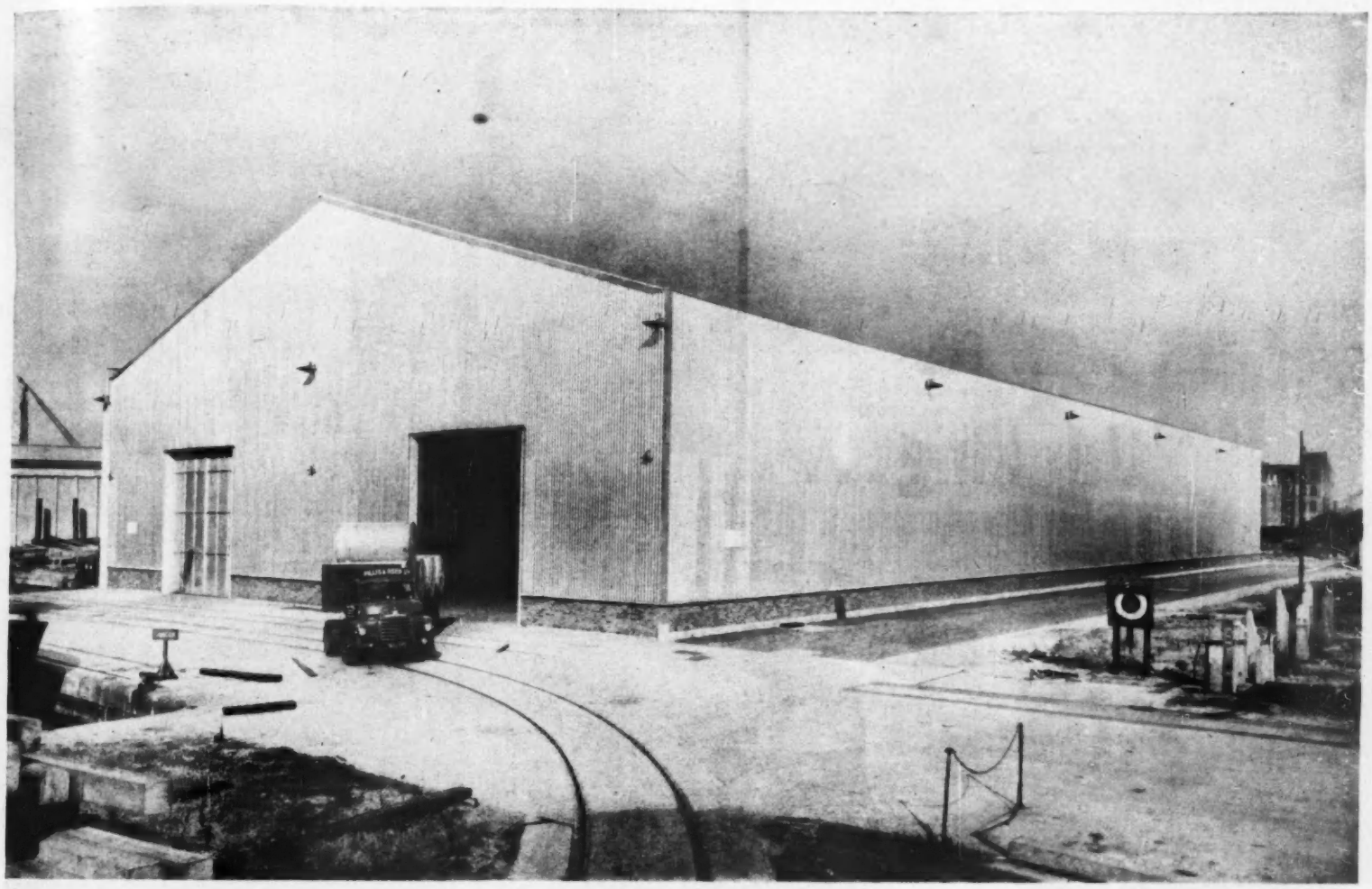

Designed and constructed under the supervision of G. A. Wilson Esq., M.Eng., M.I.C.E., M.I.Mech.E., Chief Engineer, Port of London Authority.

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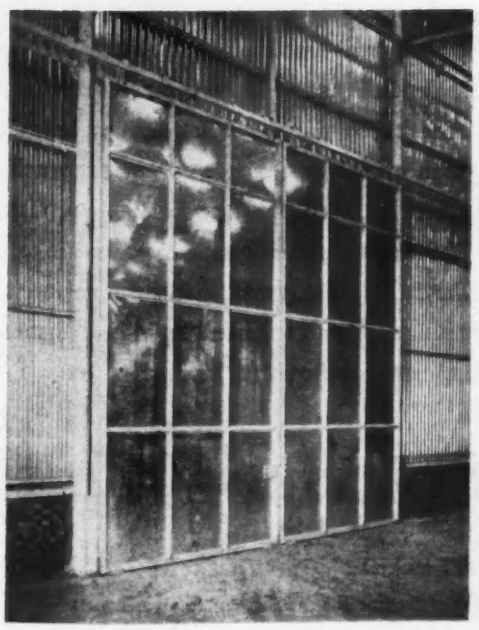

IN THE PORT OF LONDON

This warehouse at Junction Dock, West India Dock, was recently completed for the Port of London Authority. All side and end cladding is in Rigidal Industrial Trough corrugated aluminium sheet, and the sliding doors are aluminium sheet on a frame of welded aluminium sections.

British Aluminium building sheet needs little maintenance, and will last a lifetime in this marine environment.

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The BRITISH ALUMINIUM Co Ltd

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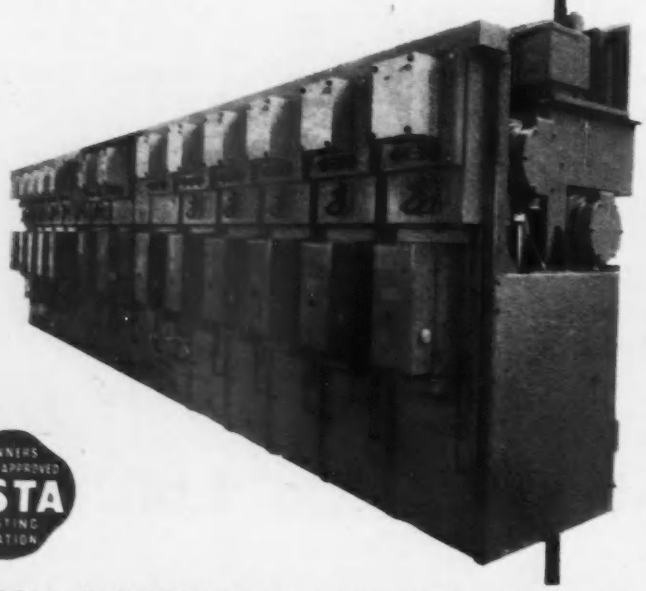
AP 329

It takes feeling as well as thinking...

What exactly does 'design' mean? Some electrical engineers restrict it to mathematical design which results in a set of figures. But this is only the half-way house. No shop could work to those figures. Design in its full sense must surely include everything that dictates what shall be made—down to the working drawings and detailed production methods. In these later stages less can be calculated, more depends on knowledge and on that cerebral computer, 'imagination', which fed with experience, often delivers its answer as an unquestioned certainty: as a direct feeling for the right job. How right these answers are depends on the experience of the designer—and of the company for which he works.



Take switchgear for example

The designers who worked on our ranges of oil-immersed and air-break switchgear had abundant data—from text-books, published research, and above all, the detailed analysis of numerous tests carried out at our own test station at Chelmsford—one of the most up-to-date in the country. Yet, even with all this, as soon as they put pencil to paper they were faced with decisions that could only be made on experience. Not necessarily their own, more often the corporate experience of the design office, works, installation engineers . . .

It is for such slowly accumulated 'know-how' that the name of a long-established company stands.

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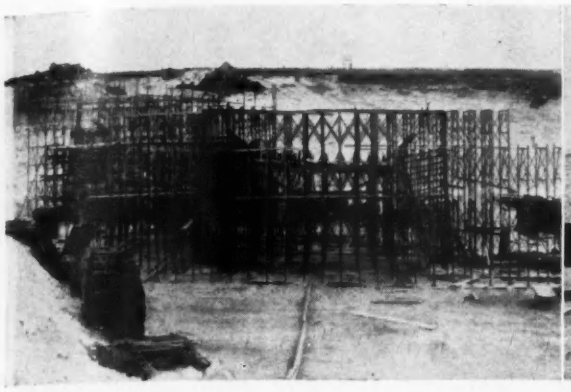
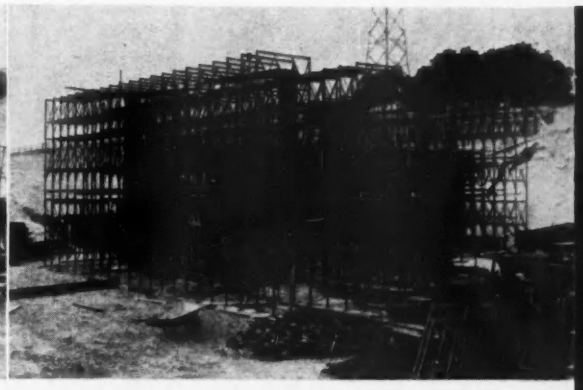
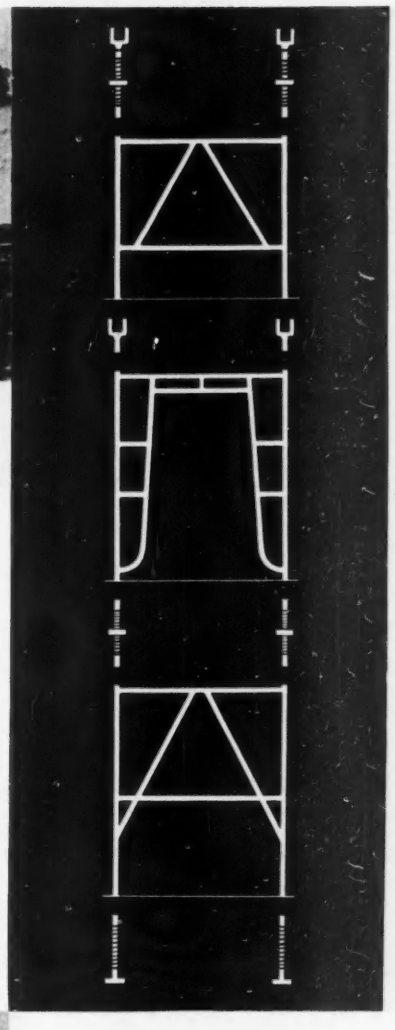




The photographs show Sterling Safway Scaffolding in use at No. 6 Bridge on St. Albans Bye-Pass built by Messrs. TARMAC Ltd.

The pre-fabricated unit frames are light to handle, strong and rigid in use and are available in various heights to a standard width of 5 ft., 2 ft. 6in. x 2 ft. allowing access through the scaffolding where required. Safway can be bought, hired or supplied on contract inclusive of labour and transport.



A supporting role in building Britain's New Motorways . . .

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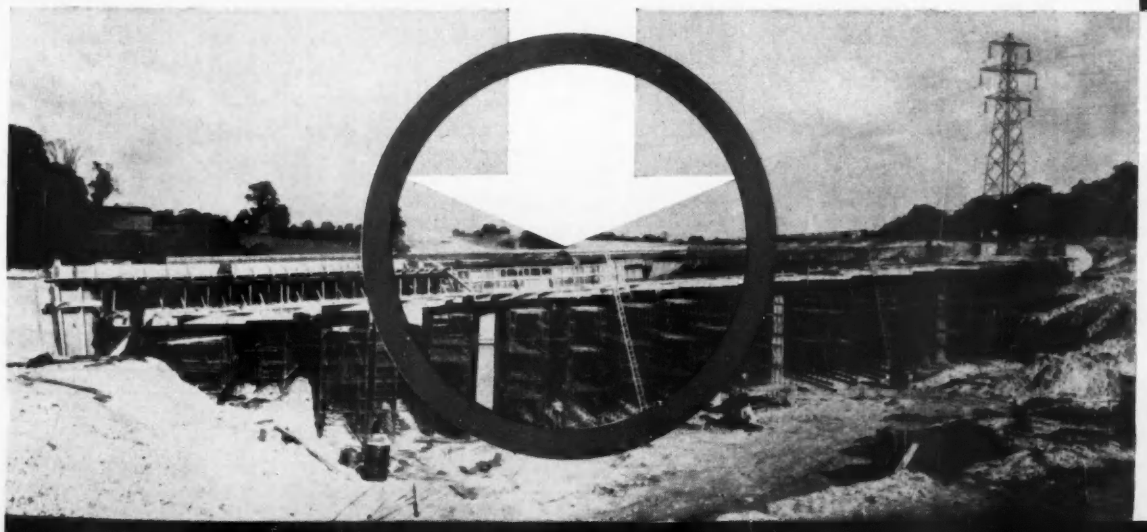
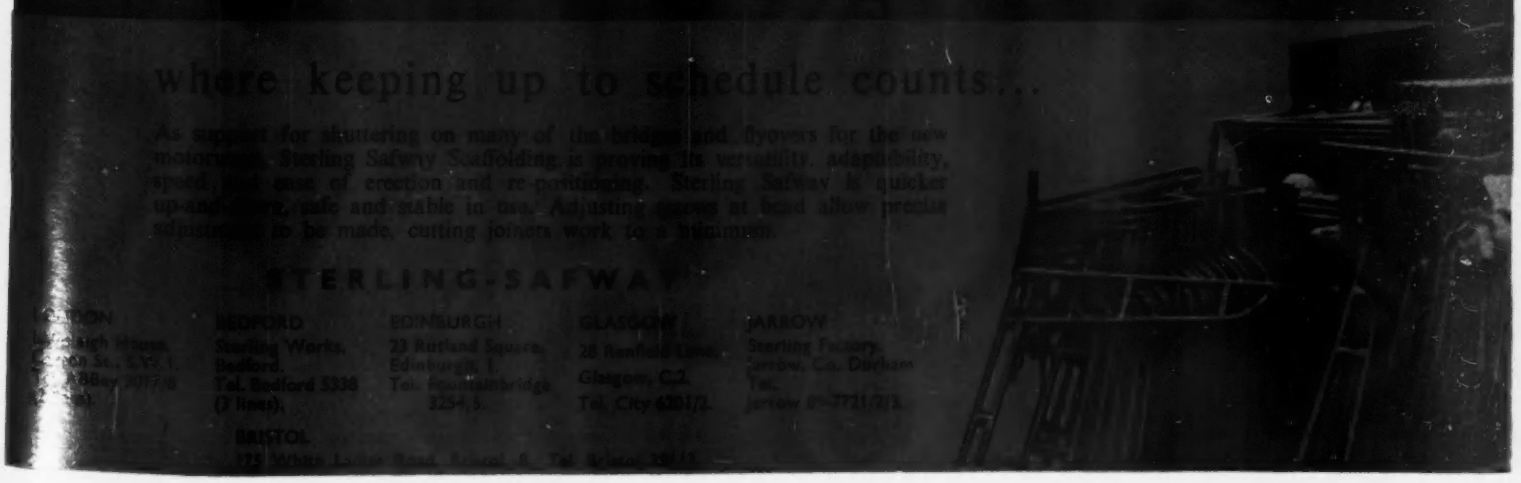


Large load-bearing structures easily and quickly built from standard Sterling Safway Unit Frame Scaffolding

SCAFFOLDING



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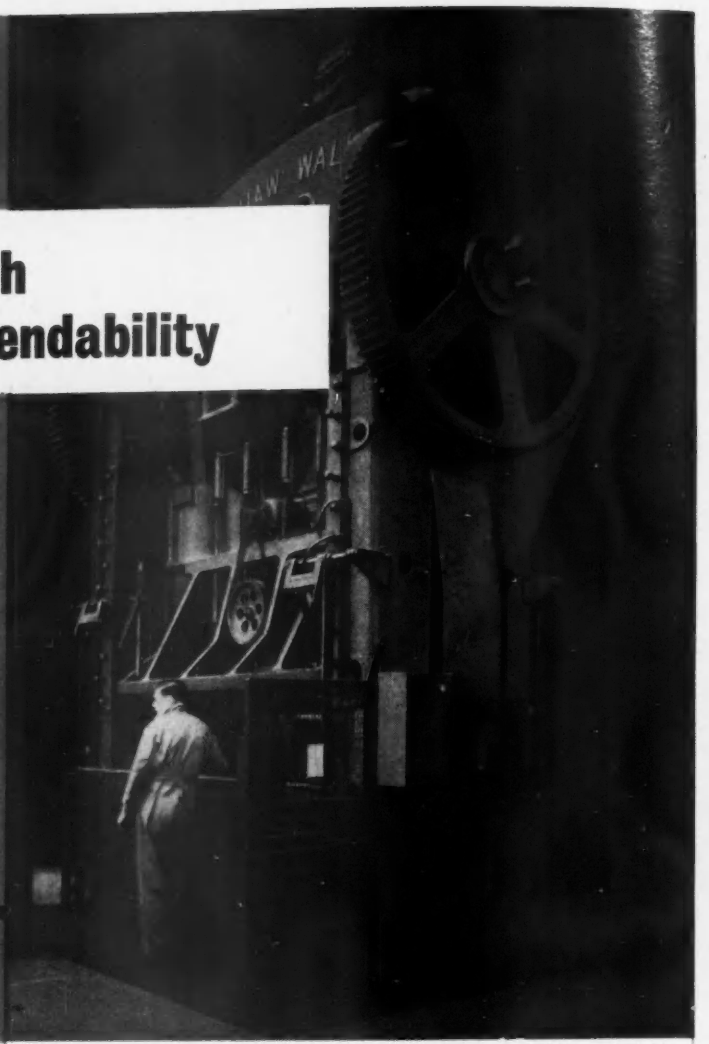

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It is with this range of large double crank tie rod presses that Cowlishaw, Walker & Co. Ltd have built their reputation for fine dependable machines. Note the clean lines, the massive frame, and the exceptionally deep slide which ensure absolute die rigidity under the most adverse conditions of loading. All models in this range are fitted with the C.W. patent electro-pneumatic clutch-brake unit.

A selection from the range of C.W. double-crank presses

PRESS TYPE	OC.10	MF.14	UF.16	LN.24	YV.34
RATING: TONS	150	300	400	650	1500
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BETWEEN SIDES ins.	75½	63	109½	109½	130½
STROKE ins.	10	14	16	24	34
SLIDE F to B x R to L ins.	30 x 68½	42 x 54	54 x 99½	63 x 99	70 x 120
BED F to B x R to L ins.	36 x 72	60 x 61	60 x 108	76 x 108	70 x 129
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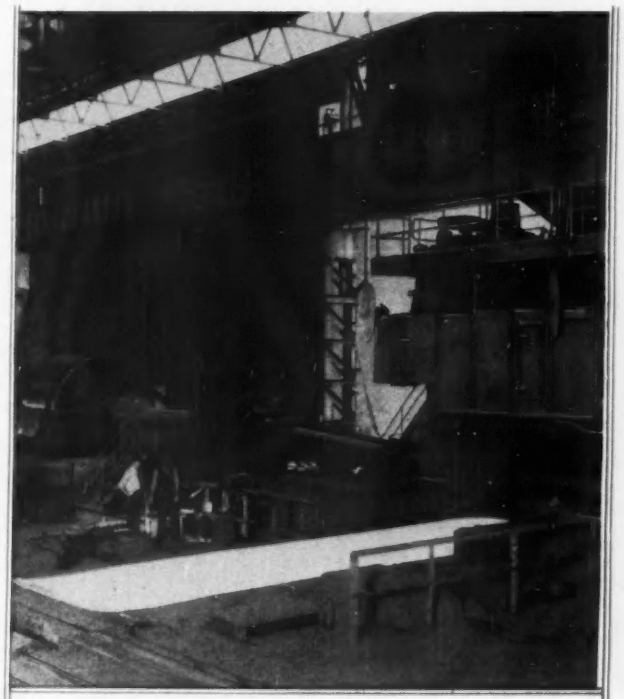

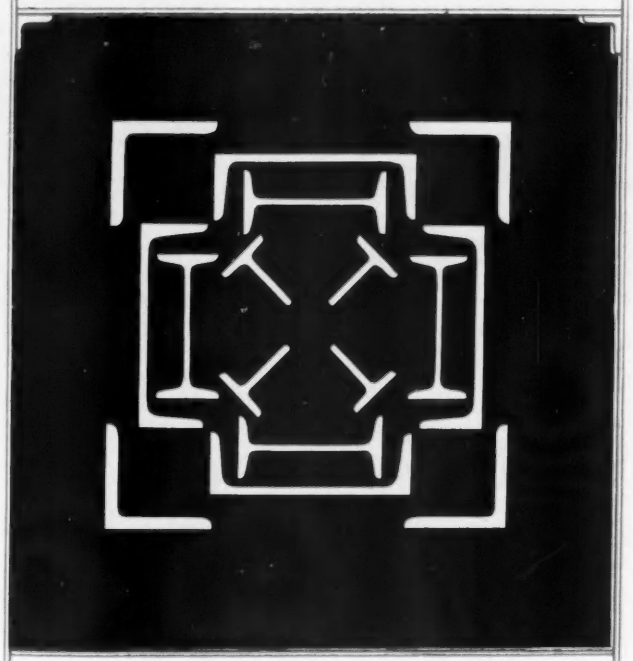

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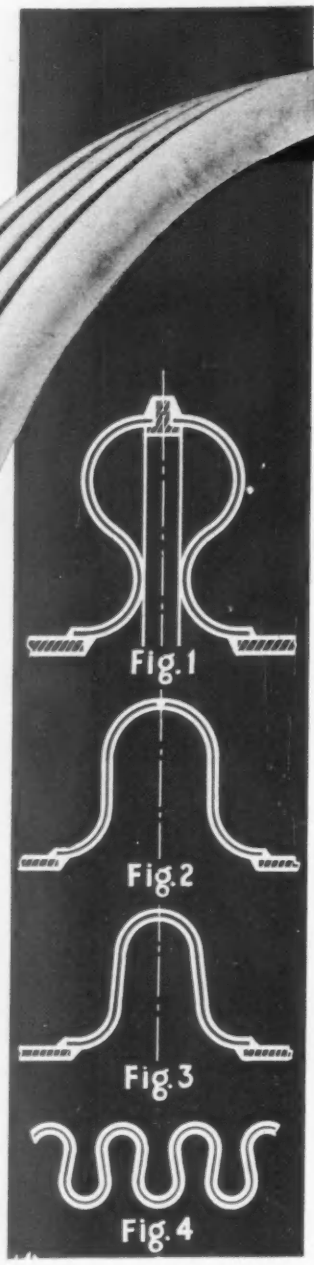

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Fig. 1 Bellows expansion fitting formed by "S" pressings. Any multiple of bellows up to five in number can be supplied in sizes from 3 in. to 84 in. bore.

Fig. 2 An alternative bellows profile particularly suitable for transverse movement. The height of the bellows is varied to suit individual pressures and working conditions.

Fig. 3 A bellows profile which may be formed by deep pressing. This type of expansion fitting is built up in three or more sections with longitudinal welds.

Fig. 4 One of the profiles available for the Aiton "A" type expansion fitting. This unit is made by a special process which obviates the need for circumferential welding at the crown of, and between, convolutions.

Illustrated are an expansion unit 10 ft. in diameter fabricated as in Fig. 3, and a 10 in. internal diameter cargo oil line expansion fitting in stainless steel.

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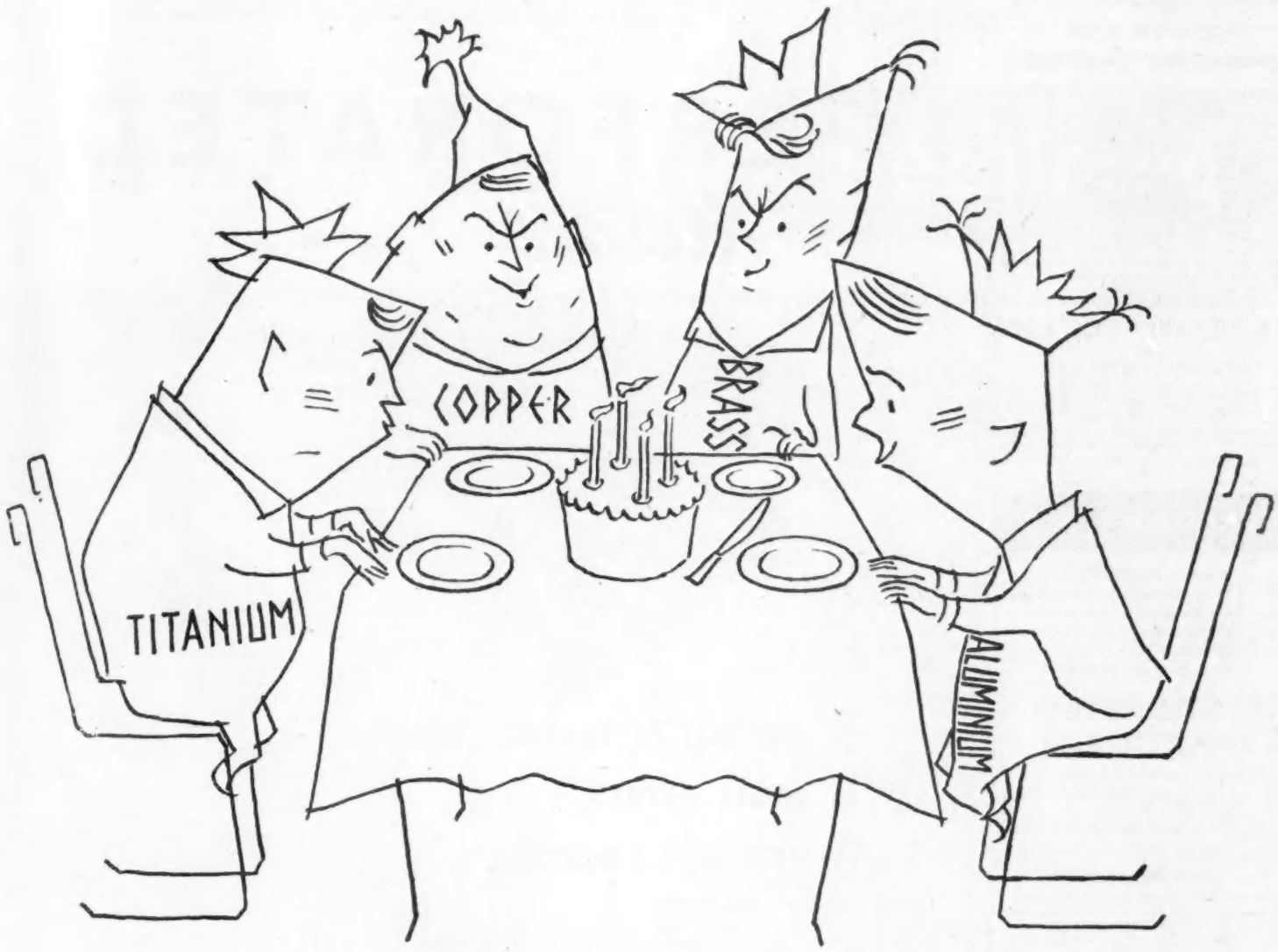

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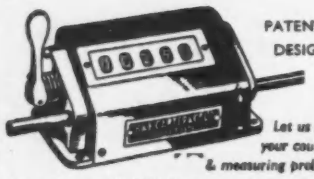

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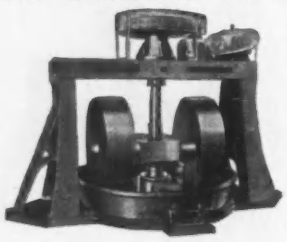

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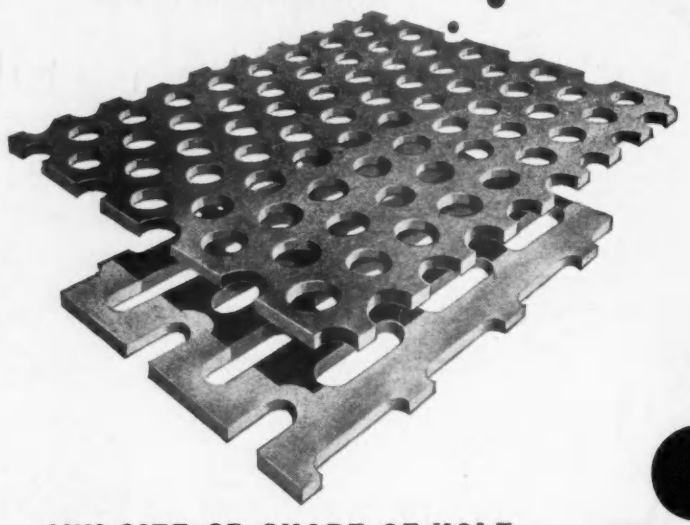

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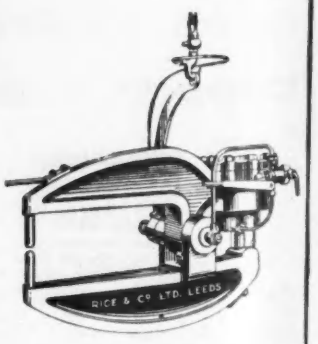

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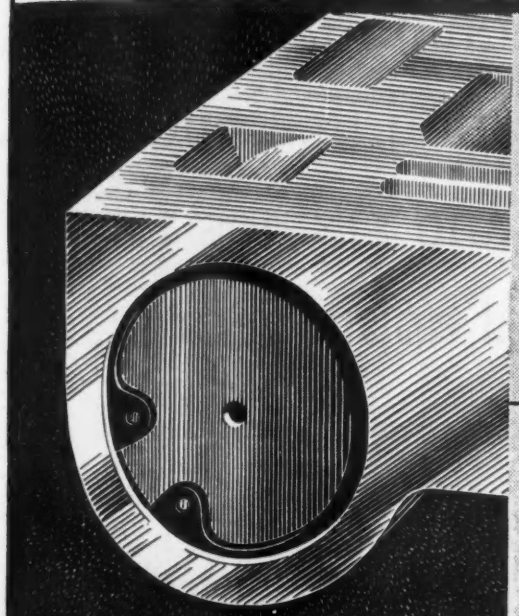
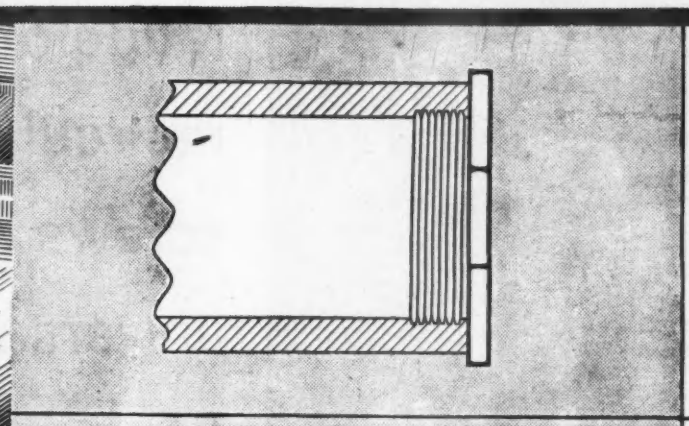
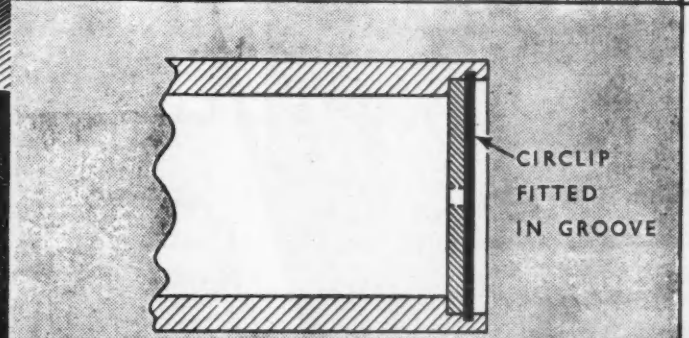




OLD WAY

This fluid seal involved internal threading of the tube, which was sealed with an expensive cap-nut. The assembly was laborious and spanners were needed.



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The tube is recessed and then simply grooved with the SALTER Grooving Tool. A Circlip is snapped into position and secures the fluid retaining plate with positive, vibration-free locking. When necessary the Circlip can be removed quickly and easily.

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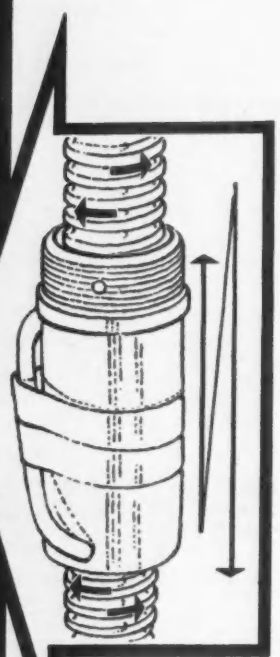

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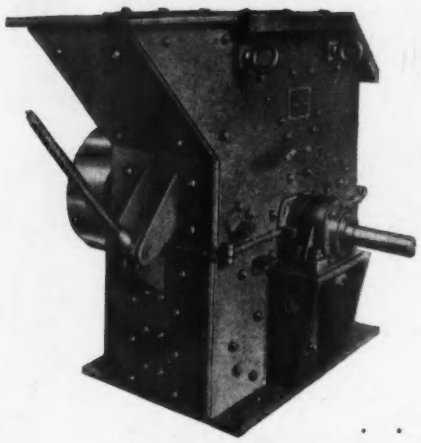

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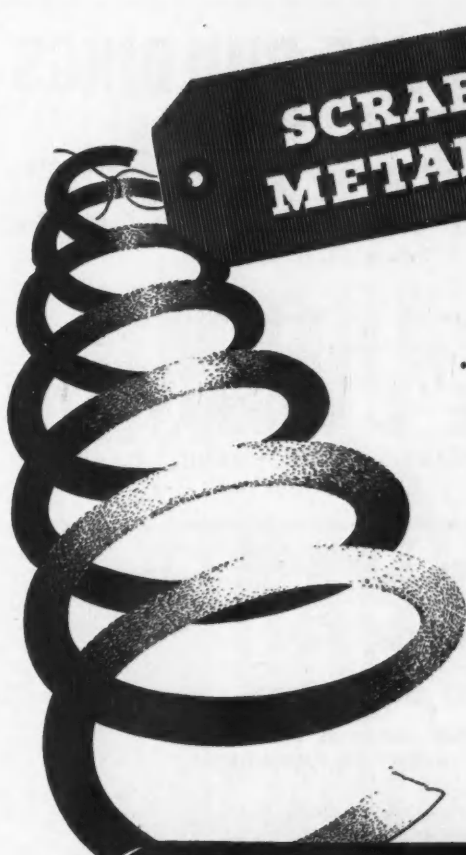

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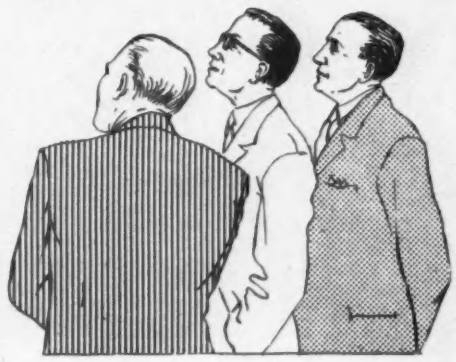

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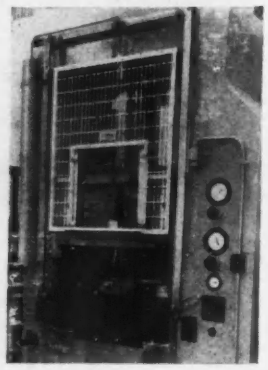

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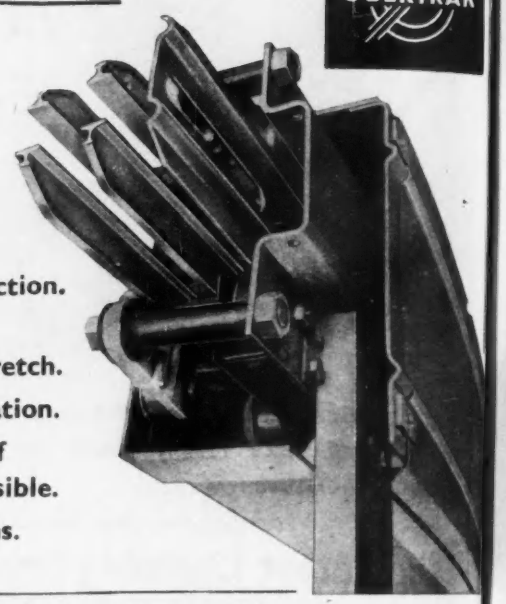

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A Herbert No. 14/36 Combination Turret Lathe, with special tooling for machining cylinder engine liners : installed in the Rugby Works of the English Electric Company. Machined in a total time of 5 hours, four operations. External diameters are held to ±0·001in., bore parallel, concentricity and ovality to ±0·002in.

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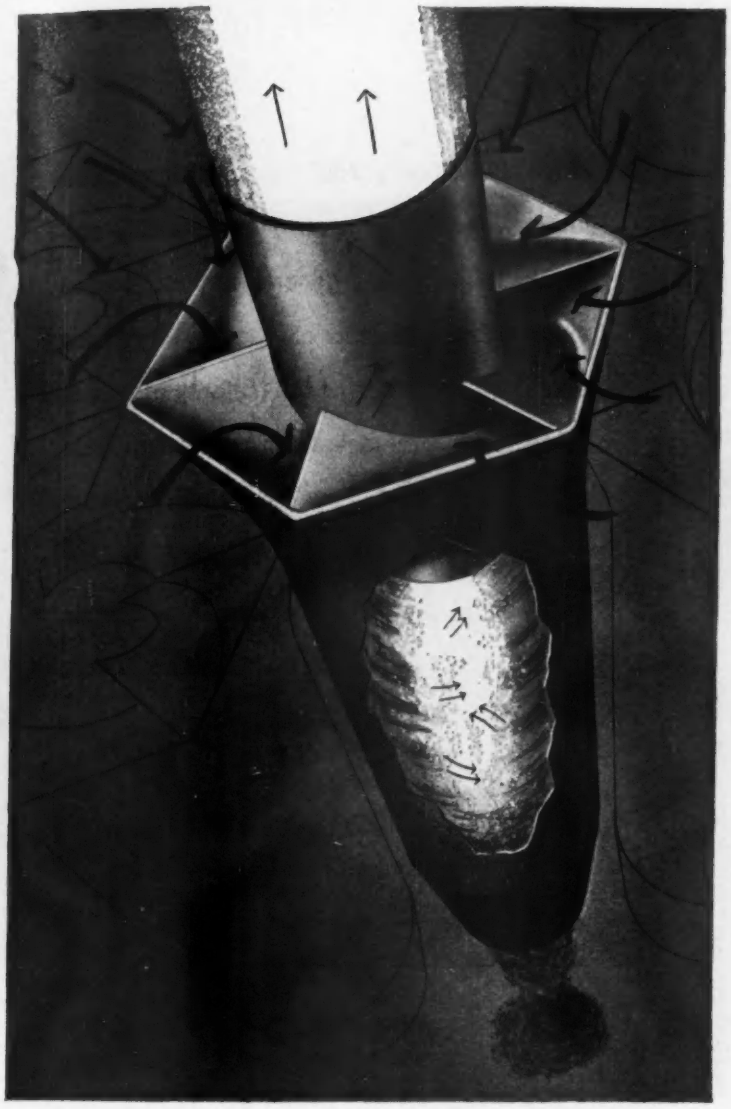

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Factory assembly ensures dimensional precision and rigidity.

Hundreds of satisfied users throughout Europe and the U.S.A. testify to the efficiency of this system

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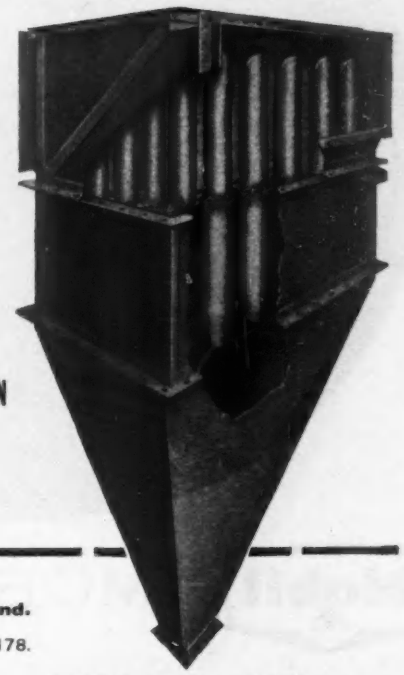
P PARTICLE
A ACCELERATION



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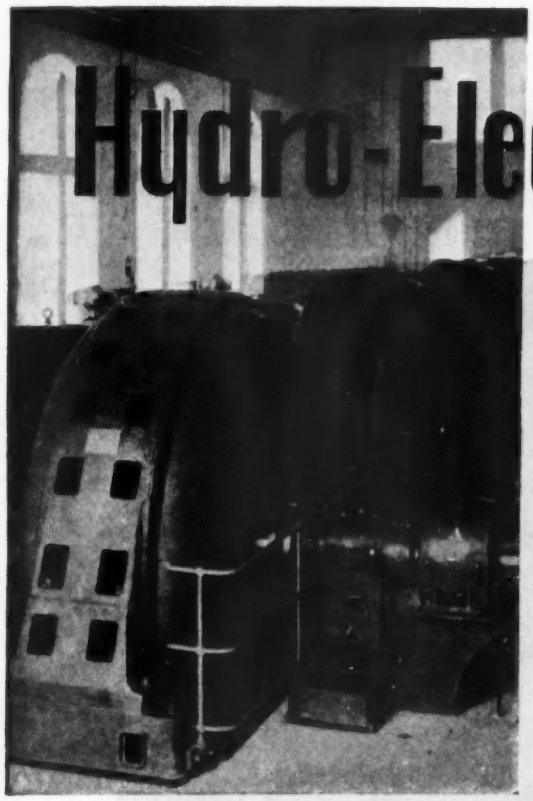
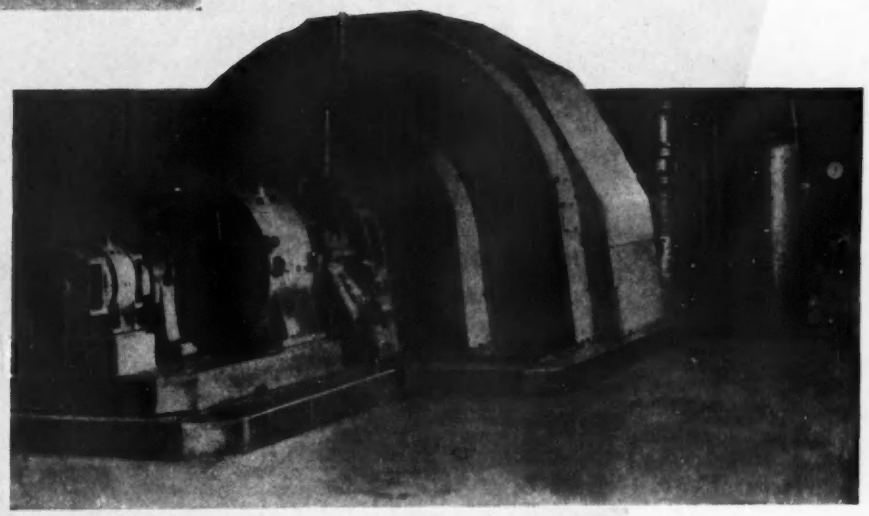


Hydro-Electric Generators

Fifty years ago Bruce Peebles engineered the Snowdon Hydro-Electric Scheme — from tunnelling to transmission lines—the first large project for public supply in Great Britain.

The original Cym Dyli Power Station, pictured at left, is equipped with four 1,500 kVA twin pelton wheel driven generators, which are still running.

These early generators were the fore-runners of the large machines being built to-day for service in many parts of the world.



14,000 kVA hydro-electric generator installed in the Yksnelvane power station, Firdakraft, Norway.

Half a century has elapsed since the first Hydro-electric scheme was completed. The pioneering spirit is still dominant and is revealed to-day in the many contracts undertaken for large hydro-electric plant for many schemes at home and abroad. Ample resources for manufacture and testing enable the largest contracts to be undertaken.

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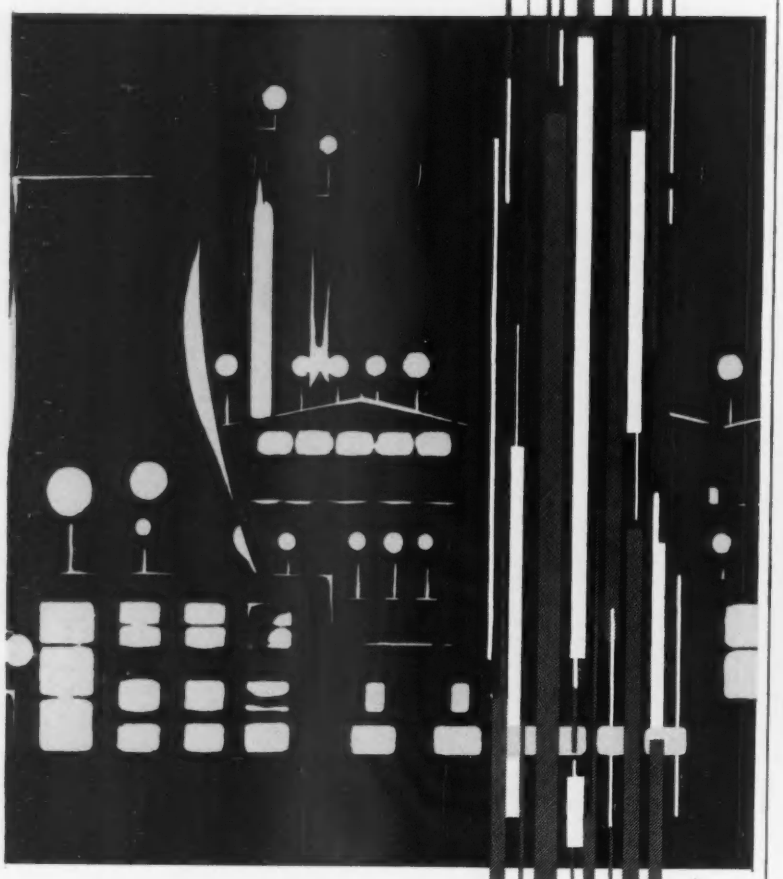

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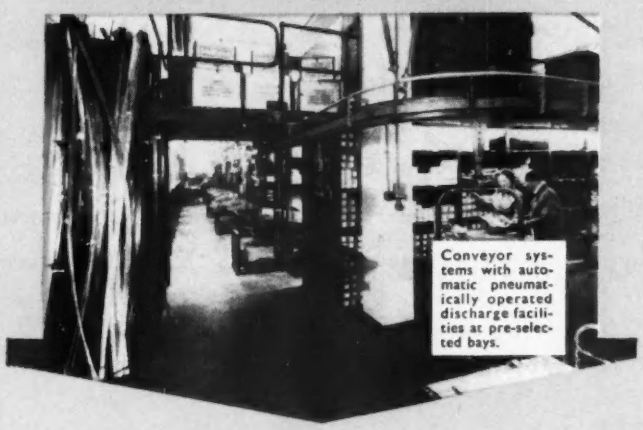
Enots staff operating the modern stock control system.

This photograph illustrates the modern pre-packaging bay.



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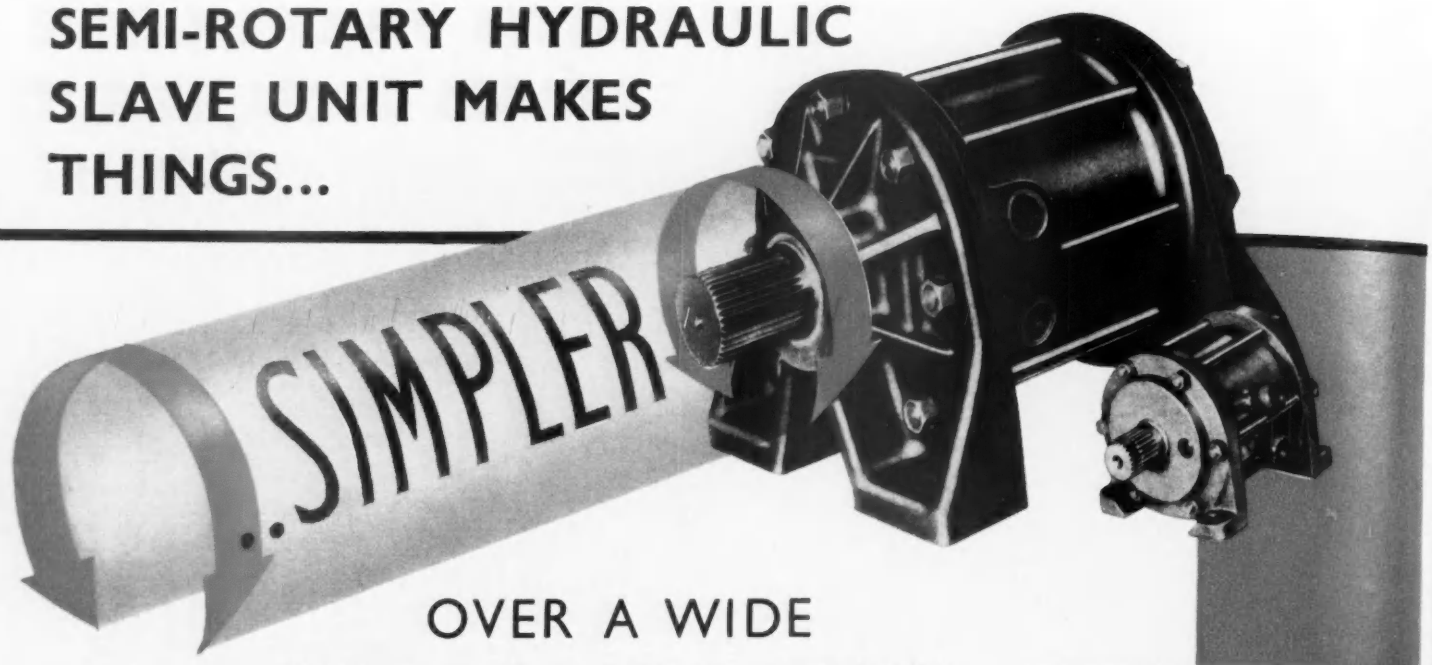

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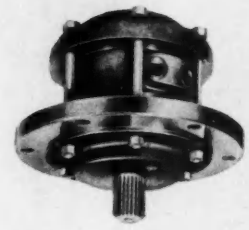
THESE double-acting units give semi-rotary motion up to 300° for single vane and up to 120° for double vane units with torques ranging from 1,270 to 1,100,000 lb/ins. at 1,000 p.s.i. Autoloc mechanical locking can be incorporated and shafts may project at either or both ends. Units can be arranged for foot or flange mounting. Normal maximum operating speed is 2 radians per second.

They have wide application in any field in which oscillatory angular motion is required and are particularly appropriate for the operation of plug valves, vanes, doors, stirring or agitating equipment, sand slingers, etc.

This is just one group of a wide range of Lockheed hydraulic units of which full details will be sent on request. Lockheed engineers are always ready to advise upon the use of units, devise schemes of hydraulic operation and control and install complete hydraulic systems.



This flange-mounted semi-rotary slave lends itself to many uses, including operating stirrers for liquid and semi-liquid products, and actuating plug or butterfly valves, where the unit can be flange-mounted directly on the valve body: many other such applications are easily arranged.

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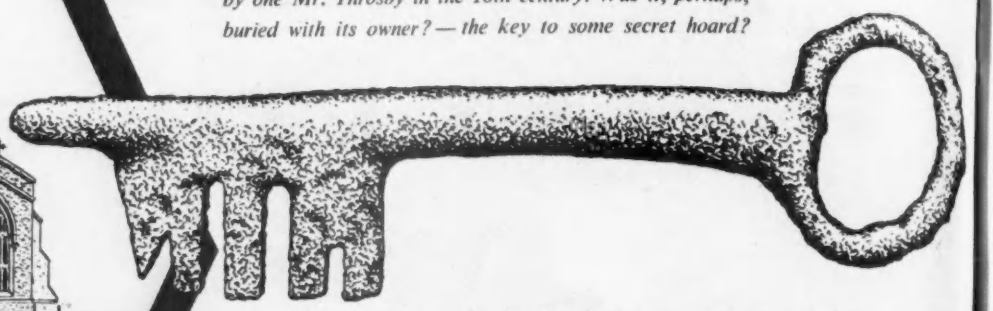
STEEL KEY TO INDUSTRY

No. 33

It is fascinating to speculate on the probable history of this ancient key found in a grave in St. Margaret's churchyard by one Mr. Throsby in the 18th century. Was it, perhaps, buried with its owner? — the key to some secret hoard?

ST. MARGARET'S CHURCH, LEICESTER

In Church Gate, Leicester, St. Margaret's shows mainly Trans-Norman work but has a very fine south porch and tower in the Perpendicular style. Among the notable features are the Tudor effigy of Abbot Penny and the ancient 'dugout' chest.



Just as fascinating is the story of steel and its contribution to our modern civilisation. In fact, not only does steel make possible the good and the necessary things of life, it is also the key that will open the door of the future. Hallamshire high grade alloy and carbon steels are helping to build that future *today!*

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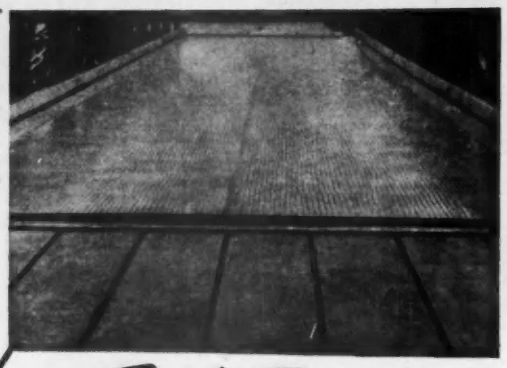
Full information on this or any other type of Bailey Bridge is readily available, from :

Bailey Bridges the Gap...



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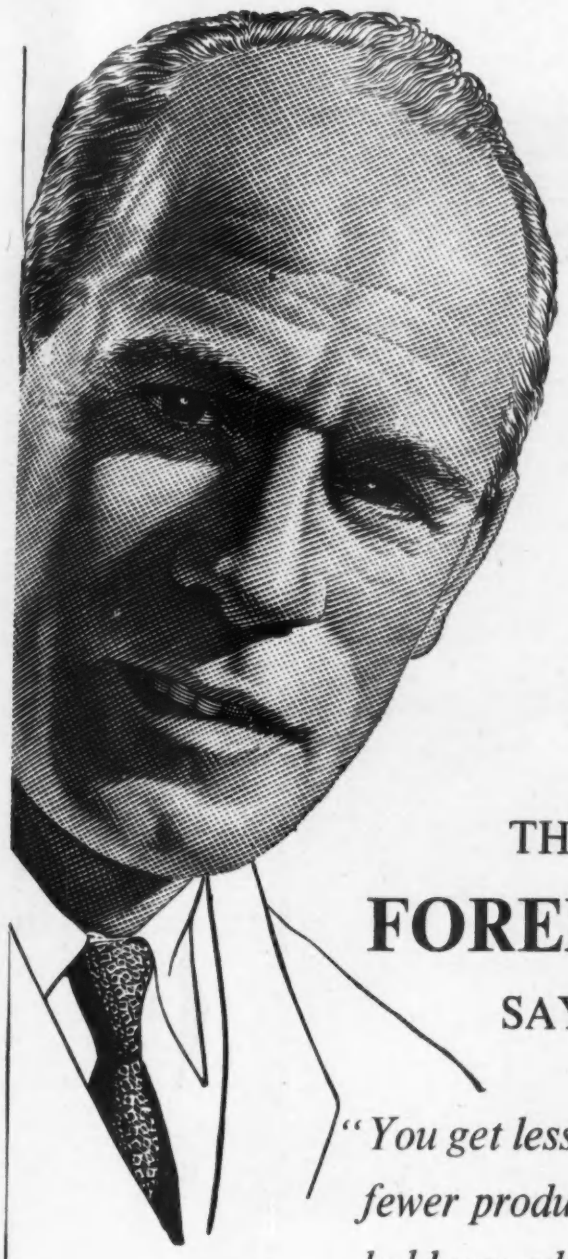

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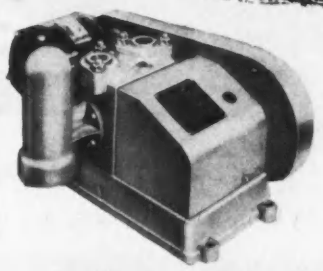
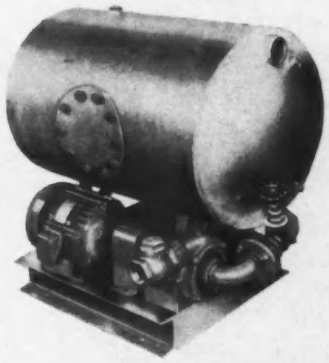


◀ GLANDLESS DIAPHRAGM PUMPS
Ideal for service in the many industries where corrosive and abrasive liquids must be pumped. Positive self-priming and can be run dry without harm.

VERTICAL SPINDLE SUMP PUMPS ▶
Automatic pumps designed specifically for sump drainage. Sturdy, self-contained and reliable under the most difficult conditions.



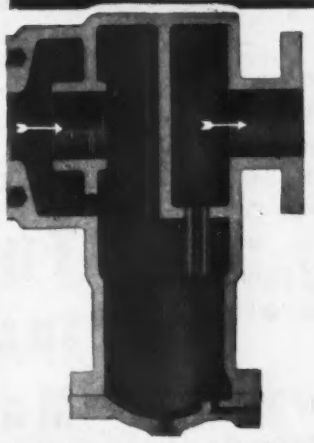
◀ CONDENSATE RETURN UNITS
Designed for the collection and return of condensate to the boiler house. Compact, automatically operated, these units combine a receiving tank, motor driven centrifugal pump and control gear mounted on a steel base. Tanks and pumps can be supplied for independent installation.

CENTRIFUGAL PUMPS ▶
Outstanding in performance and reliability these ball-bearing centrifugal pumps range in size from ¾" to 5" for continuous industrial applications. Constructed of cast iron or bronze, with smaller sizes in stainless steel.

GIRDLESTONE PUMPS LTD
23 Davies Street, London, W.1. Telephone: MAYfair 1354/5 and 5317.
TIB.147

"The Lancaster" REGD TRADE MARK

IMPACT SEPARATOR

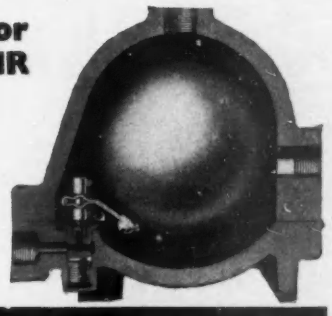


FOR SEPARATING OIL or WATER from COMPRESSED AIR or STEAM.

Large numbers are in use in Colliery Air Mains, Compressor Intercoolers, Spray Painting Plants, and many other installations where dry air is essential.

CAN BE SUPPLIED COMBINED WITH TRAP or SEPARATE AIR TRAP.

SPHERICAL FLOAT TRAP for STEAM or COMPRESSED AIR



"The Lancaster" Air Trap consists of a sealed float which rises and opens a discharge valve when the water collects in the trap. It presents a DEAD seal against leakage of air when draining water from Compressed Air Apparatus. Two alternative inlets are provided, vertical or horizontal. Will lift the discharge water. Supplied in ½in., ¾in. and 1½in. sizes.

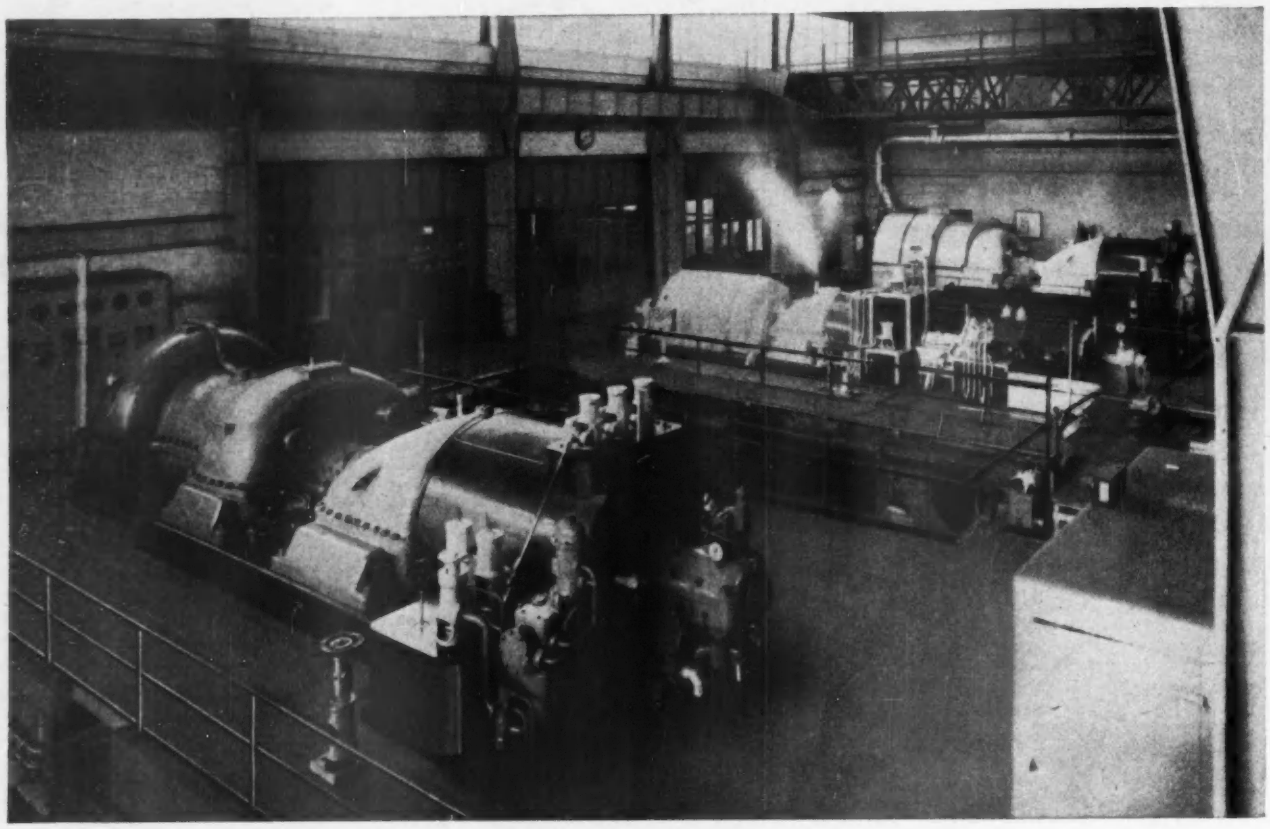
Manufacturers of "The Lancaster" Steam Traps for all purposes.

Send us your enquiries—over 70 years' experience is at your disposal.

LANCASTER & TONGE LIMITED
PENDLETON · MANCHESTER · ENGLAND
TELEPHONE: PENDLETON 1484/5/6 TELEGRAMS: PISTON MANCHESTER

SULZER

1834-1959 *A Century and a quarter of engineering*



1

2

Axial flow blower for blast furnace, Type AC 12st. 75 supplied to the Steel Company of Wales, Port Talbot Margam 'B' Station

Air intake 140,000 c.f.m.

Delivery Pressure 35 p.s.i.g.

Power input 12,000 k.w.

the second Turbo-Compressor installed at Margam 'B'

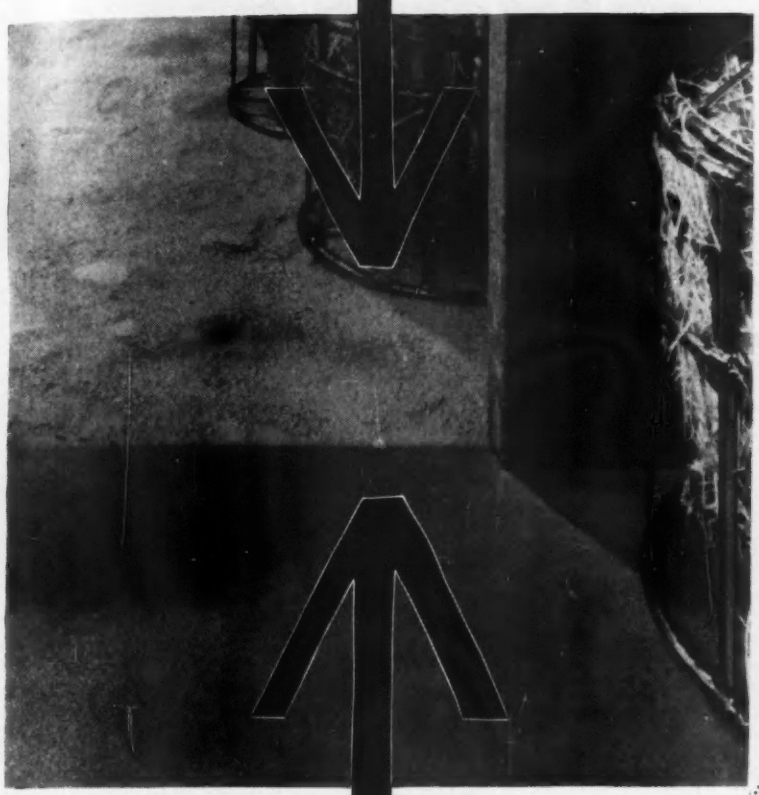
write for literature to:

SULZER BROS. (LONDON) LTD.

31 Bedford Square, London, W.C.1

Telephone: MUSeum 7890

SOLVE INDUSTRIAL FLOORING PROBLEMS WITH



Concreted Factory Floor after 3 months wear showing untreated and Ceradek treated surfaces.

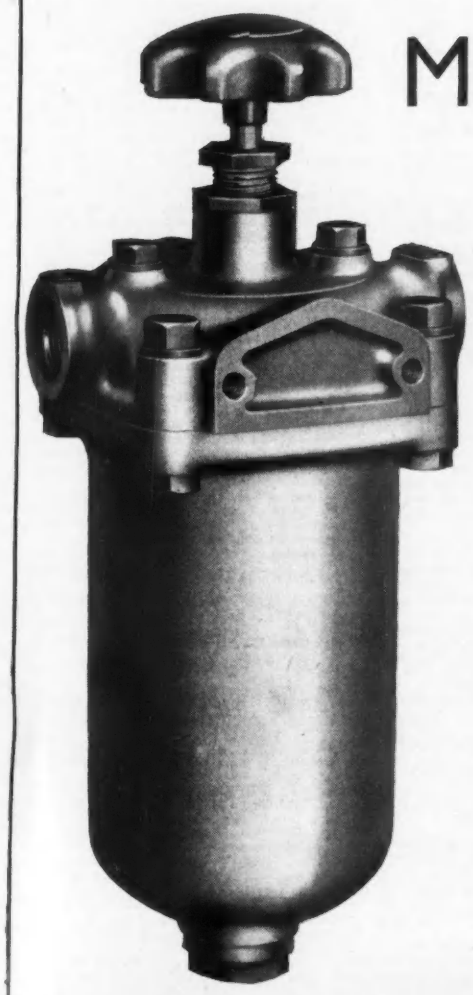
Ceradek screeded surfacing is resistant to most chemicals. Dry or wet it provides a safe non-slip surface. It obviates dust hazards and can be laid in continuous, unbroken surfaces which have great resilience and high impact strength. Ceradek is light in weight and is available in four colours—Red, Blue, Green and Brown. It withstands heavy traffic; there is no shrinkage after laying and it bonds tenaciously to various surfaces (old or new concrete etc.).

Many times stronger than concrete, Ceradek is the complete, protective surfacing which offers large scale economies and hard-wearing, long life. Suitable for an almost unlimited number of industrial applications, Ceradek provides the most likely solution to your flooring problems. Our technical staff will gladly advise you on all aspects of Ceradek installations, supplying further details and quotations as required.

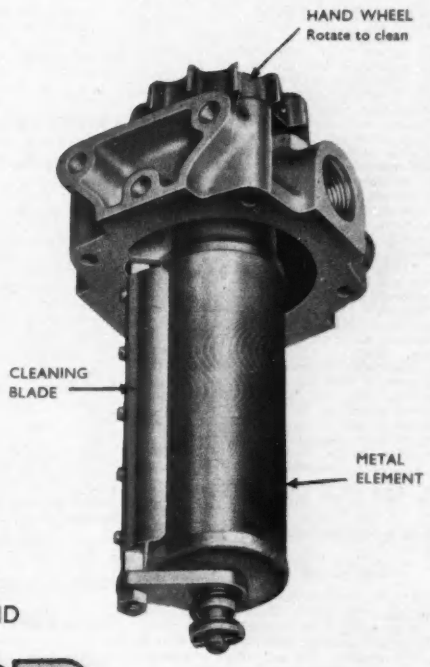
Ceradek SCREEDED FLOORING

Write or phone: **TECHNICAL APPLICATIONS LTD.**
VALLEY WORKS · MONTON ROAD,
ECCLES LANCASHIRE · Eccles 1737.

METAL-EDGE FILTERS



These filters incorporate the Purolator precision-wound metal element which presents a series of knife-edged orifices to the incoming fluid. This ensures that all arrested contaminant remains on the outer surface of the element so that it can easily be cleaned off. The type shown here is fitted with a mechanical cleaning device which will remove dirt from the element whilst it is actually working. A range of sizes from $\frac{3}{8}$″ to 2″ B.S.P. is available and element spacings from ·002″ to ·020″ can be provided.



AUTOMOTIVE PRODUCTS COMPANY LIMITED
LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

PUROLATOR

Regd. Trade Mark: Purolator

One of the Automotive Products Group

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page, (12 column inches) and upwards, e.g. ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

Advertisements for publication should be addressed to:—**Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF GRIMSBY

EDUCATION COMMITTEE

COLLEGE OF FURTHER EDUCATION

Principal: E. S. GREEN, B.Sc., A.R.I.C.

APPOINTMENTS

Applications are invited from suitably qualified men or women for the following full-time posts:
DEPARTMENT OF ENGINEERING AND BUILDING.
ASSISTANT LECTURERS, Grade "B," to teach up to O.N.C. standard in one of the following:
(10) MECHANICAL ENGINEERING.
(11) ELECTRICAL ENGINEERING.
(12) WORKSHOP ENGINEERING (either Workshop Practice, Craft Practice, Welding or Sheet metal work).
(13) ASSISTANT LECTURER, Grade "A," to teach Engineering Drawing, Science and Calculations in City and Guilds Courses.
Salary: Lecturer, £1260–£1417 10s.
Grade "B," £682 10s.–£1076.
Grade "A," £498–£945.
Application forms may be obtained from the undersigned and should be returned within fourteen days of the appearance of this advertisement. Canvassing will disqualify.

R. E. RICHARDSON,
Director of Education.

Education Office,
Eleanor Street,
Grimsby.
6th May, 1959. E5848

UNIVERSITY OF MANCHESTER

RADIO TELESCOPE—DUTY CONTROLLER

A vacancy exists for a post of DUTY CONTROLLER in connection with the 250ft. steerable radio telescope at the Jodrell Bank Experimental Station of the University of Manchester. The commencing salary, which will depend on qualifications and experience, will not be less than £650 per annum. The Salary Scale is now under review.
The Radio Telescope is driven by remote control and the person appointed will be required to work on a shift basis in the control room of the Telescope. Under normal conditions the duties will include the simple following of operating instructions as determined by the research programmes, but quick judgment may be necessary when emergencies arise. The duties include the routine maintenance of the electronic control equipment and instrumentation in the control room. Candidates must be physically fit, with good eyesight, and be capable and willing to work on a shift basis to cover the 24 hours. They must be capable of keeping full, accurate and tidy records relating to the duties entrusted to them. Candidates must hold a Higher National Certificate in Electrical Engineering, or a senior City and Guilds Certificate in some branch of light current electrical engineering or similar qualifications. Previous experience of the control of plant or apparatus containing both electrical and mechanical parts is desirable.
Applications, giving full details of qualifications and experience as well as the names and addresses of two referees, should be sent to Professor A. C. B. Lovell, Jodrell Bank Experimental Station, Lower Withington, Macclesfield, Cheshire. E5852

CIVIL SERVICE COMMISSION

H.M. DOCKYARD TECHNICAL COLLEGES

TEACHING POSTS

Teaching posts in H.M. Dockyard Technical Colleges. Pensionable (non-contributory) ASSISTANT LECTURER posts for men: three at Devonport for: (1) English with a modern language; (2) Physics, and (3) Mechanical Engineering; one each at Chatham and Rosyth for Electrical Engineering. Ability to help with other subjects essential. Appointment September, 1959, or as soon after as possible.

Qualifications: University Degree or equivalent and ability to teach special subject to H.N.C. standard. Burnham scales for Technical Colleges. Final year students may apply.

Write: Civil Service Commission, Burlington Gardens, London, W.1, for application form, quoting 4981/59. Closing date 10th June, 1959. E5788

PUBLIC APPOINTMENTS

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE

CEMENT AND CONCRETE ASSOCIATION STUDENTSHIP

Applications are invited for the above-mentioned STUDENTSHIP, of the value of £400 per annum, which is available for post-graduate work in the Department of Civil Engineering.
The Studentship is open to Graduates of an approved University who have shown, or seem likely to show, ability as a research worker. It is tenable for two years, but may be renewed for a third year in special circumstances.
Forms of application and further particulars may be obtained from the undersigned, to whom completed forms should be returned as soon as possible.

G. R. HANSON,
Registrar of King's College.
May, 1959. E5847

NORWICH CITY COLLEGE AND ART SCHOOL,

IPSWICH ROAD, NORWICH

Principal: FRANK BRIERS, B.Sc., D.Phil.(Oxon) F.R.I.C.

LECTURER IN ELECTRICAL ENGINEERING

Wanted for 1st September, 1959, or as soon as possible thereafter, LECTURER IN ELECTRICAL ENGINEERING for Higher National Diploma, Ordinary and Higher National Certificate and City and Guilds Electrical courses. Applicants should possess a University degree, A.M.I.E.E. or equivalent, and have had teaching and suitable industrial experience.
Salary £1260 by £31 10s. to £1417 10s.
Application forms, which may be obtained from the Director of Education, City Hall, Norwich, on receipt of a stamped, addressed envelope, should be returned to the Principal as soon as possible. E5882

KENT EDUCATION COMMITTEE

ERITH TECHNICAL COLLEGE

ASSISTANTS

Applications are invited for the following appointments, to commence in September, 1959:
Two ASSISTANTS, Grade "B," to teach General Engineering subjects up to O.N.C. and O.N.D. Mechanical Engineering. Preference will be given to applicants having an Engineering Degree and/or Corporate Membership of one of the major Engineering Institutions. Industrial experience is essential and some teaching experience desirable.
One ASSISTANT, Grade "A," to teach General Engineering to earlier years, as above.
Salary in accordance with the Burnham Technical Scale:
Grade "B"—£682 10s. by £26 5s. to £1076 5s.
Grade "A"—£498 15s. by £26 5s. to £945.
Plus London allowance of £37 16s. or £50 8s.
Application forms from the Principal at the College, Erith Road, Belvedere, Kent, to whom they should be returned as soon as possible. E5840

UNIVERSITY OF LEEDS

DEPARTMENT OF CIVIL ENGINEERING

LECTURER IN AIRCRAFT STRUCTURES

Applications are invited for appointment as LECTURER IN AIRCRAFT STRUCTURES in the Department of Civil Engineering, at a salary on the scale £900 by £50 to £1350 (efficiency bar) by £75 to £1650 a year. Practical experience in the Aircraft Industry is essential and some research experience is desirable. In addition, a knowledge of general Civil Engineering subjects would be an advantage. Applications (three copies) stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than 20th June, 1959. E5830

PUBLIC APPOINTMENTS

SINGAPORE POLYTECHNIC

DEPARTMENT OF ENGINEERING

LECTURERS

The Board of Governors invite applications for the following appointments in the Department of Engineering:
(a) SENIOR LECTURER IN ELECTRICAL ENGINEERING;
(b) LECTURER IN MECHANICAL ENGINEERING;
(c) ASSISTANT LECTURER, GRADE III IN PRODUCTION ENGINEERING.
Qualifications: (a) Degree; A.M.I.E.E.; industrial experience and teaching experience in Technical College or University essential; (b) Degree and/or A.M.I.Mech.E.; experience as for (a). (c) Full Technological Certificate of City and Guilds in Machine Shop Engineering or H.N.C. with Production endorsements, and industrial experience in machine tool practice essential; O.N.C. and teaching experience desirable.
Monthly Salary Scales (including allowances): (a) M$1800 by M$50 to M$1950; (b) M$1600 by M$50 to M$1750; (c) M$1200 by M$50 to M$1550; (one M$—2s. 4d. at present).
Appointment of overseas persons is on contract for three years. Favourable Endowment Insurance Scheme; or the College will be prepared to take over and maintain employer's contributions to former F.S.S.U. policies. Accommodation, with heavy furniture at rental of M$120 p.m.; free medical attention, and half cost of maintenance in hospital; free passage for member of staff, his wife and up to 3 children under 18, on first appointment, leave and completion of service; home leave at rate of 60 days per year's service, normally taken on completion of 3 years' service.
Application forms (4 copies) and further information obtainable from Council for Overseas Colleges, 12, Lincoln's Inn Fields, London, W.C.2. Closing date, 5th June, 1959. E5878

UNIVERSITY OF SHEFFIELD

POSTGRADUATE DEPARTMENT OF APPLIED MECHANICS

LECTURER

Applications are invited for a post of LECTURER in the Postgraduate Department of Applied Mechanics to begin duties on 1st October, 1959. Preference may be given to a candidate with a knowledge of the theory and practice of Mechanisms and Automatic Controls. Initial salary according to qualifications and experience on the scale £900 by £50 to £1350 by £75 to £1650, with F.S.S.U. provision and family allowance. A grant towards removal expenses will be made. Further particulars should be obtained from the Registrar, to whom applications (4 copies) should be sent by 20th June, 1959. E5831

UNIVERSITY OF BRISTOL

LECTURERS

Applications are invited for two posts as LECTURER (one Grade II and one Grade III) in the Department of Mechanical Engineering, at an initial salary within the range:
Grade III £700 to £850 per annum
Grade II £900 to £1650 per annum
according to qualifications and experience, with F.S.S.U. benefits and Family Allowance. Applicants should have good academic qualifications and practical experience.
Further particulars may be obtained from the undersigned to whom applications (including the names of two persons to whom reference may be made) should be sent not later than June 8th, 1959.

H. C. BUTTERFIELD,
E5888 Registrar and Secretary.

SURREY EDUCATION COMMITTEE

WIMBLEDON TECHNICAL COLLEGE, GLADSTONE ROAD, S.W.19

GRADE "B" ASSISTANT

Grade "B" ASSISTANT required as soon a possible, to teach MECHANICAL ENGINEERING subjects to Ordinary National Certificate level, particularly Mathematics. Preference given to Graduates or the equivalent. Salary, Burnham Scale: £682 10s. by £26 5s. to £1076 5s., plus London Allowance.
Application form and further particulars obtainable from the Principal, to whom completed applications should be sent within two weeks of appearance of advertisement. E5865

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF BRIGHTON EDUCATION COMMITTEE

BRIGHTON TECHNICAL COLLEGE

Principal: G. E. WATTS, M.A., Ph.D.(Cantab), B.Sc.(Lond.), F.R.I.C.

LECTURER

Required: LECTURER in Engineering Metallurgy for engineering degree and diploma courses, with Degree in Engineering or Metallurgy or corporate membership of appropriate professional institution, prepared to teach at least one other mechanical engineering subject. Salary scale: £1260 by £31 10s. to £1417 10s. Increments may be allowed for approved industrial, professional, or research experience.
Further particulars and application forms from the undersigned to be returned to the Principal, Brighton Technical College, Richmond Terrace, Brighton, 7, as soon as possible.

W. G. STONE,
Director of Education.
54, Old Steine,
Brighton. E5897

CITY OF BRADFORD

ENGINEERING ASSISTANTS

Applications are invited for the following superannuable appointments in the City Engineer and Surveyor's Department, on the grades indicated.
(a) SENIOR ENGINEERING ASSISTANT (Post 18), A.P.T. IV (£1065–£1220).
(b) SENIOR ENGINEERING ASSISTANTS (Posts 13 and 119), Special Grade (£750–£1030).
(c) ENGINEERING ASSISTANTS (Posts 37 and 120), Grade A.P.T. I or Special (£610–£765 or £750–£1030, according to qualifications).
(d) JUNIOR ENGINEERING ASSISTANTS (Posts 63, 65, 174), Grade A.P.T. I. (£610–£765).
Applicants for Post (a) should preferably hold an Engineering Degree, be A.M.I.C.E./A.M.I.Mun.E., and have had special experience in design of reinforced concrete and steel structure for Multi-Storey Flat construction.
Applicants for (b) should preferably hold an Engineering Degree, be A.M.I.C.E./A.M.I.Mun.E., and have had a good general civil engineering training.
Applicants for (c) should have completed their professional training. Salary on Special Grade will be payable to the successful candidates holding an Engineering Degree or is A.M.I.C.E./A.M.I.Mun.E.
Applicants for (d) should have completed their professional training and have had experience in Municipal and/or Civil Engineering.
Applicants should have completed their National Service. No housing accommodation can be provided by the Corporation.
Applications on form to be obtained from the City Engineer and Surveyor, Town Hall, Bradford, 1, together with three testimonials must be received by the undersigned by 2nd June 1959.

W. H. LEATHEM,
Town Clerk.
Town Hall, Bradford, 1. E5854

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

HYDRAULICS RESEARCH STATION, WALLINGFORD, BERKS

ASSISTANT EXPERIMENTAL OFFICERS OR EXPERIMENTAL OFFICERS

D.S.I.R. Hydraulics Research Station, Wallingford, Berks, requires ASSISTANT EXPERIMENTAL OFFICERS or EXPERIMENTAL OFFICERS for work on scale models of hydraulic projects in civil engineering field. Qualifications: G.C.E. "A" level in two science or maths. subjects or equivalent. Over 22, Pass degree, H.N.C. or equivalent generally expected. Experience of engineering drawing and/or constructional work an advantage for some posts. Salary ranges: (men) A.E.O's £382 10s. (age 18) to £670 (age 26) to £830. E.O. £954 to £1166. Women slightly less. Five-day week. Promotion prospects. Housing facilities for married staff. Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting E.316/8A. Closing date 12th June, 1959. E5832

PUBLIC APPOINTMENTS

GOVERNMENT OF WESTERN NIGERIA

VACANCIES FOR EXECUTIVE ENGINEERS

Applications are invited from suitable candidates for posts of EXECUTIVE ENGINEER.

Qualifications: Candidates who should be between 25–50 years of age, must have a regular University Degree recognised by the Institution of Civil Engineers or exemption from the final Parts I and II of the Institution's Examination, and should have at least two years' appropriate post qualification practical experience.

Duties: The successful candidates will be required to undertake preliminary surveys and investigations and to supervise the construction either by direct labour or by contract of road and bridge works in the Region.

Terms of Appointment: On contract terms with gratuity for a minimum of two tours of 12–18 months each, in the first instance, on Salary Scale "A," £846 by £42 to £1380 plus 35 per cent. contract addition; point of entry depending on qualification and experience. In addition an Inducement pay of £240–£270 per annum plus a supplementary pay of £120 per annum is payable. Free first class passages for officer and his family on first appointment and when proceeding on leave, free medical treatment for officer and his family; furnished quarters provided at a rent of 8½ per cent. of basic salary.

Applications should be completed in duplicate on the prescribed form obtainable from the Official Secretary (Recruitment Branch), Office of the Commissioner for Western Nigeria, 178/202, Great Portland Street, London, W.1, from whom further particulars may also be obtained.

Closing date: 30th May, 1959.

E5845

WEST DORSET WATER BOARD

APPOINTMENTS

Appointment of:
(a) ASSISTANT ENGINEER, A.P.T. IV (£1065–£1220 per annum).
(b) ENGINEERING ASSISTANT, A.P.T. I (£610–£765 per annum).

Applications are invited for the above appointments.

Candidates for (a) must be Associate Members of the Institution of Civil Engineers and the Institution of Water Engineers, and have a thorough knowledge of Water Engineering practice, with particular reference to underground supplies, pumps and service reservoirs.

Candidates for (b) should be pursuing a course of study leading to the qualifications for appointment (a) and some intermediate examination should have been passed. General Drawing Office experience is necessary and preference will be given to candidates with some Water Engineering knowledge.

Both appointments will be subject to the provisions of the Local Government Superannuation Acts, the National Scheme of Conditions of Service and to passing a medical examination.

Forms of application and further particulars may be obtained from the undersigned and to whom applications should be returned by Monday, June 1st.

R. CHAPMAN, A.M.I.C.E., A.M.I.W.E.,
Engineer and Manager.

11, Downes Street,
Bridport,
Dorset. E5802

CITY OF NOTTINGHAM

WATER DEPARTMENT

PERMANENT APPOINTMENT—CIVIL ENGINEERING ASSISTANT

Applications for this permanent, pensionable appointment are invited from Graduate Members of the Institution of Civil Engineers and/or Engineering Graduates of a University, in each case with at least five years' experience (which need not necessarily have been with a Water Undertaking), including the period spent on theoretical training. Salary, dependent upon qualifications and experience, in the Special Grade for Engineering and Surveying Assistants (£750 by £40 to £1030).

Applications, with names of two persons to whom reference may be made, to Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, by 8th June.

T. J. OWEN,
Town Clerk.

Guildhall,
Nottingham. E5842

GOVERNMENT OF HONG KONG

MECHANICAL ENGINEER (MARINE)

To supervise maintenance of a fleet of high-speed launch engines and undertake general administration duties.

Permanent appointment. Salary: £1500–£2178, plus cost-of-living allowance. Quarters available at low rent. Free passages. Generous leave.

Candidates must be A.M.I.Mech.E., with apprenticeship and post-qualifying experience with a firm engaged in manufacture and maintenance of high-speed diesel engines. General marine engineering and machine shop experience is an advantage. Age limits 35–45 years.

Write, Director of Recruitment, Colonial Office, London, S.W.1, giving age, qualifications and experience, quoting BCD 118/51/08. E5861

PUBLIC APPOINTMENTS

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Vacancies for SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS in following localities:

LONDON AREA: MECHANICAL ENGINEER with sound knowledge of basic principles of thermo and fluid dynamics, to carry out research programme in a particular field of applied hydrodynamics. Experience in modern methods of design and research on axial flow compressors, turbines or pumps an advantage. MECHANICAL ENGINEER for work on propulsion problems. APPLIED MATHEMATICIAN for research of basic nature on stability of underwater vehicles: knowledge of theoretical hydrodynamics and theory of control systems an advantage. APPLIED MATHEMATICIAN or THEORETICAL PHYSICISTS for acoustic analysis. ELECTRONIC PHYSICISTS for data handling and analysis problems. PHYSICIST interested in operator performance. CLASSICAL PHYSICISTS.

BALDOCK: PHYSICISTS or APPLIED MATHEMATICIANS for research in Metal or Quantum Physics.

PORTSMOUTH: ELECTRONIC ENGINEERS for research on analogue computers and transistor circuits. ELECTRICAL ENGINEERS for research on small rotating electrical machinery. PHYSICISTS—for optical systems and instrumentation. ELECTRO-MECHANICAL ENGINEERS — for work on servo-mechanisms.

PORTLAND: PHYSICISTS or APPLIED MATHEMATICIANS for research on underwater acoustics. ELECTRONIC PHYSICISTS, ELECTRONIC ENGINEERS—for design work. PHYSICAL CHEMISTS.

POOLE: CHEMICAL ENGINEERS. CHEMISTS for work on rubber technology.

ROSYTH: PHYSICISTS (Electronic).

Candidates must normally be natural born British subjects of natural born British parents, with First or Second-Class Hons. Degrees. S.S.O.s must have had three years' post-graduate experience and be not less than 26 years of age. Salaries: (men) S.S.O., £1233–£1460; S.O., £655–£1150 (London), somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.220/9A). E5866

GOVERNMENT OF WESTERN NIGERIA

VACANCIES FOR EXECUTIVE ENGINEER, GRADE I

Applications are invited from suitable candidates for posts of EXECUTIVE ENGINEER, Grade I.

Qualifications: Candidates, who should be between 28–50 years of age, must be a Corporate Member of the Institution of Civil Engineers and must have had at least seven years' appropriate experience after gaining a University Degree in Civil Engineering, or passing Parts I and II of the Institution of Civil Engineers Examination. Must also have Structural Engineering Design, Reinforced Concrete and Foundation Design experience. Candidates must also have experience of site investigations for foundations and laboratory testing, road and bridge layout design and construction.

Duties: The successful candidates will be required to take charge of the Structural and Civil Engineering Design Section of the Ministry of Works and Transport.

Terms of Appointment: On contract terms with gratuity for a minimum of two tours of 12–18 months each, in the first instance, on Salary Scale A (U), £1188 by £48 to £1380, plus 35 per cent. contract addition; point of entry depending on qualification and experience. In addition, an Inducement pay of £270–£300 per annum, plus supplementary pay of £120 per annum is payable. Free first-class passages for officer and his family on first appointment and when proceeding on leave, free medical treatment for officer and his family; furnished quarters provided at a rent of 8½ per cent. of basic salary.

Applications should be completed in duplicate on the prescribed form, obtainable from the Official Secretary (Recruitment Branch), Office of the Commissioner for Western Nigeria, 178/202, Great Portland Street, London, W.1, from whom further particulars may also be obtained.

Closing date: 30th May, 1959.

E5846

EAST ANGLIAN REGIONAL HOSPITAL BOARD

ASSISTANT ENGINEER (MECHANICAL)

Candidates should be Grad.M.I.Mech.E. and/or A.M.I.H.V.E., or equivalent, with experience in design and installation of heating, ventilating, steam boiler plant and services, &c., as applicable to hospitals. Salary: £730–£1055—additional increments within scale based on experience and age may be granted.

Applications, giving full details of age, qualifications, experience and present salary, &c., with names of three referees, to Secretary of Board, 117, Chesterton Road, Cambridge, by 1st June, 1959. E5777

PUBLIC APPOINTMENTS

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

NATIONAL ENGINEERING LABORATORY, EAST KILBRIDE, GLASGOW

PRINCIPAL SCIENTIFIC OFFICERS

Three pensionable posts at National Engineering Laboratory, East Kilbride, Glasgow, for men or women, viz: (a) PHYSICAL METALLURGIST to be responsible for metallurgical aspects of research on plasticity over a wide field from metal physics through properties of materials to investigation of formation and cutting processes such as extrusion and machining; (b) ENGINEER or PHYSICIST to take charge of fundamental research on cutting; (c) ENGINEER interested in hydrodynamic lubrication to lead research on dynamically loaded bearings and factors governing bearing instability. Qualifications normally first or second class honours degree in a scientific subject (including Engineering), or high professional attainment. Appropriate research experience essential. Industrial experience an advantage. Salary scale (men) £1420–£2020. Starting pay may be above minimum. Good housing prospects. Write Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting S4986/59/14. Closing date 25th June, 1959. E5877

BRITISH RAILWAYS

RESEARCH DEPARTMENT (ENGINEERING DIVISION), DERBY

SCIENTIFIC OFFICER, GRADE 2

Vacancy for SCIENTIFIC OFFICER GRADE 2, initially to study problems connected with dynamics of trains, shocks to goods in transit, &c. Candidates should have good degree. Previous experience of research not essential. Consideration given to candidates about to take their degree, engagement being subject to their subsequent passing at required standard.

Salary: £665 to £985 per annum (according to qualifications and/or experience).

Superannuation and certain travel facilities.

Medical examination.

Applications stating age, experience, &c., to:
Director of Research,
British Railways Research Dept.,
222, Marylebone Road,
London, N.W.1. E5838

ADMIRALTY

SHIP DEPARTMENT, BATH

NAVAL ARCHITECTS

Admiralty require NAVAL ARCHITECTS for unestablished posts for DESIGN ASSISTANTS in Ship Department, Bath. British subjects with University Degree (or equivalent) in Naval Architecture and practical shipyard experience. Salaries for the two available grades assessed according to age, qualifications and experience, to maxima £1290 and £2050, respectively. Only exceptionally well-qualified candidates considered for higher grade. Five-day week.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting reference C339/9A. Closing date, 15th June, 1959. E5844

NORTH WEST METROPOLITAN REGIONAL HOSPITAL BOARD

PANEL OF CONSULTING ENGINEERS

The Board maintains a Panel of Consulting Engineers for use in connection with the execution of buildings and engineering schemes in hospitals, and applications are now invited from practising mechanical, electrical and heating and ventilating engineers for addition to the list.

Applications, giving the names and qualifications of each partner, together with the names and addresses of two referees, should be submitted to the Secretary, North West Metropolitan Regional Hospital Board, 40, Eastbourne Terrace, London, W.2, by 17th June, 1959. E5837

THURROCK URBAN DISTRICT COUNCIL

ENGINEER AND SURVEYOR'S DEPARTMENT

ENGINEERING ASSISTANT

Thurrock Urban District Council (Engineer and Surveyor's Department) require ENGINEERING ASSISTANT. Salary within A.P.T. I/II: £610–£880 per annum. Candidates should have completed their training in a Municipal or Civil Engineer's Office and have had some subsequent experience. Appointment pensionable.

Applications, stating age, qualifications and experience, and quoting three referees, to Clerk of the Council, Council Offices, Grays, Essex, by 26th May, 1959. Canvassing disqualifies. Relationship with Members or Senior Officers of the Council must be disclosed. E5778

HACKNEY BOROUGH COUNCIL

ENGINEERING ASSISTANT

ENGINEERING ASSISTANT required by Hackney Borough Council. Grade A.P.T. I/II (£610–£880 p.a.). London Weighting Allowance £30 p.a. at age 26. Commencing salary according to training, qualifications and experience.—Apply Town Clerk, Town Hall, Hackney, E.8, for application form returnable by 9 a.m., Monday, 8th June, 1959. E5856

TENDERS

KINGDOM OF THAILAND

ROYAL IRRIGATION DEPARTMENT

BANGKOK, THAILAND

INVITATION FOR BIDS—NO. YS-2-9

The Royal Irrigation Department of the Kingdom of Thailand hereby invites sealed written BIDS for FURNISHING and DELIVERING the following GOODS, EQUIPMENT and MATERIALS, either f.o.b. Contractors' shipping point or c.i.f. Bangkok Wharf, Thailand, for the Bhumiphol Dam and Power Plant, Yanhee Multipurpose Project, Kingdom of Thailand, in accordance with the Contract documents, for:

The fabrication of approximately 1·8 million kilograms (4 million pounds) of steel into penstocks and outlet pipe, including the furnishing of all necessary material, labour and equipment. It is required that the various pieces be furnished in approximately 4·50m. to 4·15m. inside diameter by 7·315m. length (14ft. 9in. to 13ft. 7in. inside diameter by 24ft. length) in varying thickness from ¼in. to 1 ¼in. Several bends, including some of the reducing type and one bifurcation are required. Transportation facilities are not adequate for these overall dimensions, necessitating a field fabrication plant at the Dam Site. The dam and power plant are located approximately 420 kilometres or 260 miles north of Bangkok, Thailand.

Bids will be opened early August, 1959. Copies of contract documents, invitation for Bids—No. YS-2-9, may be obtained by qualified Bidders on written request, addressed to:

Royal Irrigation Department,
Attention: Thai Liaison Engineer,
c/o Engineering Consultants, Inc.,
1940 West Mississippi Avenue,
Denver 23, Colorado.

Each request must be accompanied by a cheque or money order, payable to the Royal Irrigation Department, in the amount of U.S. $10.00 for each copy of the contract documents requested. The remittance is non-returnable.

M. L. XUJATI KAMBHU,
Director General.
Royal Irrigation Department,
Kingdom of Thailand,
Bangkok, Thailand. E2415

MADRAS PORT TRUST

The Office of the Madras Port Trust, Madras, India, invites TENDERS for the following:

(a) TENDER ENQUIRY No. 2190/59/EP/5.
For the SUPPLY of 3 (Nos.) DIESEL ENGINE DRIVEN OPERATOR PORTABLE WELDING SETS with an output of 20 to 400 amps.

(b) TENDER ENQUIRY No. 2190/59/EP/5.
For the SUPPLY of 2 (Nos.) UNIVERSAL MILLING MACHINES, table size 54in. by 12in., traverses 30in. long by 13in. across by 18in. vert.

(c) TENDER ENQUIRY No. 3645/59/E.P./4.
For the SUPPLY of a PORTABLE DIESEL-DRIVEN AIR COMPRESSOR, 300/350 cu. ft./min. at 100 p.s.i.

Specifications, drawings, &c., relative to the above Tender enquiries can be obtained direct from the Deputy Chief Accounts Officer (Engineering), Chief Engineer's Office, Madras Port Trust, Madras 1, India, on payment of: (a) 13s. 6d. per Tender set; (b) £1 1s. per Tender set; (c) 7s. 6d. per Tender set, and will not be refunded.

Tenders are to be returned direct to the Chief Engineer ("C" Warehouse), Madras Port Trust, Madras, India, so as to reach him by: (a) 22nd July, 1959; (b) 29th July, 1959; (c) 7th July, 1959.

Specimen copy of the above enquiries can be seen at India Store Department, Government Buildings, Bromyard Avenue, Acton, W.3, under the following references:

(a) S 3143/59/NSC/ENG.2.
(b) S 3144/59/NSC/ENG.2.
(c) S 3172/59/NSC/ENG.2. E5859

COUNTY BOROUGH OF BRIGHTON

WATERWORKS DEPARTMENT

MILE OAK PUMPING STATION

AUTOMATIC PUMPING CONTROL EQUIPMENT

FIXED PRICE TENDERS invited for MANUFACTURE, DELIVERY, ERECTION, TESTING AND SETTING IN OPERATION equipment for remote and/or local automatic control of electrically driven submersible well pumps and booster pumps.

Specification and Particulars from Chief Engineer Water Department, 12, Bond Street, Brighton, 1, on payment of Two Guineas deposit to be refunded on receipt of a bona-fide tender and return of all documents.

Tenders in the plain sealed envelope provided not bearing any name or mark indicating the sender, endorsed "Tender for Remote/Automatic Control, Mile Oak," to be delivered to me by noon on 8th August, 1959. The Corporation do not bind themselves to accept the lowest or any tender.

W. O. DODD,
Town Clerk.
Town Hall,
Brighton, 1. E5881

Classified Advts. continued on page 120

TENDERS

CITY OF NOTTINGHAM

WATER DEPARTMENT

MARKHAM CLINTON PUMPING STATION—ELECTRIC PUMPING PLANT

TENDERS are invited from experienced contractors for the MANUFACTURE, SUPPLY, ERECTION and SETTING TO WORK complete of Centrifugal Borehole and Booster Pumps, Electric Motors, Switchgear, Diesel Engine Alternator and other appurtenant work at Markham Clinton Pumping Station in the parish of West Markham, near Tuxford, Notts.

Specification, form of tender and drawings may be obtained from Mr. B. W. Davies, Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, on payment of a deposit of ten guineas, which will be returned on receipt of a bona fide tender not afterwards withdrawn and the return of all documents and drawings.

Sealed Tenders, endorsed "Tender for Pumping Plant, Markham Clinton Works," to be delivered at my office not later than noon on Monday, 31st August, 1959.

T. J. OWEN,
Town Clerk.

The Guildhall,
Nottingham. E5850

COUNTY BOROUGH OF SOUTHAMPTON

County Borough of Southampton invites QUOTATIONS from Steelwork Specialists for STRUCTURAL STEELWORK at new Swimming Baths, Western Esplanade to be Sub-Contractors to Main Contractor (R.I.B.A. Contract plus Supplemental Conditions available for inspection). Forms and particulars from Borough Architect on written application by 30th May, 1959. Quotation to the Town Clerk, Civic Centre, Southampton, by 12 noon on the 24th June, 1959. E5885

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London W.8. E114 B

EDUCATIONAL

AUTOMATION.—AUTHORITATIVE COURSES are now available in Digital and Analogue Computer Technology, Applied Electronics, Data Processing and Instrumentation up to professional level by home study. Individual enrolment or industrial group scheme enrolments accepted. Syllabuses and prospectus sent on request.—Write (Dept. S.E.8), E.M.I. Institute School of Electronics, College House, Kensington, London, W.8. E145 B

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

ACTIVE PROGRESS CLERK required for West End office engineering company. Interesting work connected with Railway modernisation programme. Permanent pensionable post with opportunity for advancement.—Apply in writing, stating age, salary and experience to Manager, Traction Dept., SULZER BROTHERS (LONDON), LTD., 31, Bedford Square, W.C.1.

E5855 A

CHIEF ENGINEER

General Engineers in South London with 150 employees, require Engineer to cover design work, estimating and purchasing A sound, practical man of wide experience in general engineering is required. Good salary with ample scope for real live man—age not over 42 years. Appointment subject to pension. Full details required of previous experience with responsibility entailed, also salary requirements. —BOX No. E2372, "The Engineer."

A

CHIEF RATEFIXER AND TIME STUDY ENGINEER is required immediately by a medium/heavy engineering company in the North West of England. The selected applicant must have served a recognised apprenticeship and have had wide experience in a senior capacity in time study and ratefixing applied to general engineering. This is a responsible position with real prospects for the right man. Please supply details in chronological order, giving particulars of experience, positions held and present salary.—BOX No. E5887, "The Engineer." A

COMPANY MEETING

MATTHEW HALL & CO. LIMITED

CHAIRMAN'S STATEMENT

The Thirty-second Annual General Meeting of Matthew Hall & Co. Limited was held on 19th May, 1959, at Matthew Hall House, Dorset Square, London.

The following is an extract from the circulated statement of the Chairman, Mr. Bertram Baden, M.C., S.B.St.J., M.I.H.V.E.

The year 1958 produced an increased group trading profit of £491,293 as compared with £321,854 for 1957. This was mainly due to the number of large long term contracts reaching completion during the year. The net profit after all charges including taxation, was £201,152 (1957—£99,319). The directors recommend a dividend of 30% (1957—30% on smaller capital, plus a capital dividend of 5½% free of tax).

It is also recommended that £240,000 of the Company's reserves be capitalised and applied in paying up in full 960,000 ordinary shares of 5/- each to be issued to members on the basis of one new ordinary share for each existing ordinary share. It is possible to propose such a substantial capitalisation because, during the current year, the Company's reserves will be considerably strengthened by a transfer of reserves from a subsidiary Company which is being liquidated under a reorganisation of the group's overseas activities so as to take advantage of the benefits afforded to Overseas Trade Corporations.

It is not proposed to maintain the same rate of dividend on the increased capital, but it is hoped, apart from unforeseen circumstances, that the total amount distributed next year by way of dividend will not be less than that for 1958.

Our order book is substantial although it does not reach the record levels achieved during the past two years. Competition is keen, especially in South Africa.

NUCLEAR ENERGY DIVISION

Orders included a contract for the installation of the 7,000 ton electromagnet for the 7 GeV proton synchrotron at the Rutherford High Energy Laboratory, Harwell.

Our work on a land-based prototype nuclear submarine involves special welding techniques to Lloyd's Class 1 requirements.

CHEMICAL, OIL REFINERY AND INDUSTRIAL ENGINEERING DIVISIONS

The design, procurement and construction of large oil and chemical installations were among contracts secured. These included a styrene monomer plant and extensions to an oil refinery in the West Indies and to a copper refinery in Northern Rhodesia.

Work was completed on a new chemical plant producing fuel for rocket motors; this is the first of its kind in the United Kingdom and one of the largest in the world.

The order was secured for the erection of a second 55,000 tons per annum paper making machine.

SPRINKLERS AND FIRE PROTECTION

Contracts were received for sprinkler systems to paper mills, a large power station, laboratories, garages, stores and office blocks, including the main areas of the new American Embassy office building in Grosvenor Square.

MATTHEW HALL (PTY.) LIMITED, SOUTH AFRICA

Contracts obtained included air conditioning, sprinkler systems, plumbing, electrical and mechanical services. Work on chemical, oil and industrial plants continued.

The report and accounts were adopted.

SITUATIONS VACANT

CHIEF ENGINEER required by medium-sized company of Constructional Engineers in Glasgow.

Applications are invited for the above post from Graduate Engineers of 35/45 years of age who have had good workshop experience and several years in a post of major responsibility in the field of constructional engineering and general platework fabrication. The successful applicant will be entirely responsible to the Managing Director for the design and development of all new products and new plant and for the Production Drawing Office.

The post will carry a salary commensurate with qualifications and experience, membership of an excellent Pension Scheme, and Life Assurance and Personal Accident Insurance cover. There will be first-class prospects for further advancement.

Write in confidence, with full personal particulars and details of qualifications and experience, to BOX No. E5868, "The Engineer."

A

CIVIL ENGINEERING ASSISTANTS required for Head Office and Site Vacancies in connection with electric power projects in Scotland. Preference for applicants with Engineering Degree or exemption from Parts I and II of Institution examination.—Reply, giving age, qualifications and experience, to JAMES WILLIAMSON AND PARTNERS, 219, St. Vincent Street, Glasgow. E5896 A

DESIGN DRAUGHTSMAN required for mechanical design of nucleonic instruments. Pleasant working conditions. Excellent rates of pay.—Apply Chief Draughtsman, ISOTOPE DEVELOPMENTS, LTD., Beenham Grange, Aldermaston, Berks. Tel.: Woolhampton 451. E152 A

DRAUGHTSMAN required in Pump Division of an old-established Engineering Company, Birmingham area. Must be experienced in the design and detailing of oil refinery, centrifugal process pumps and chemical pumps for the Oil Industry and Chemical Trades. Contributory pension scheme, five-day week, canteen and recreational facilities.—Apply, giving full details of training, qualifications, past employment and salary range, in strict confidence, to the Secretary, TANGYES LIMITED, Cornwall Works, Smethwick. E5762 A

ELECTRICAL CONSTRUCTION ENGINEER (qualified) required for service in India, must have experience in the planning and installation of all electrical services for a large modern engineering factory with a total loading of approximately 7000kW, including generating, distribution and application at voltages of 11kV and 400 volts. Three years' contract in first instance with prospect of renewal. Salary including allowances up to Rs.2400 per month, free quarters, medical attention, use of car, free passages for engineer and family, and other valuable concessions.—Apply, giving details of age, experience, family circumstances and references to Secretary, A.E.I., Overseas, Ltd., 33, Grosvenor Place, London, S.W.1. E5841 A

ENGINEERING COMPANY IN IPSWICH wishes to strengthen existing drawing-office staff by appointment of two keen DRAUGHTSMEN, ages 24–28, with at least O.N.C. The office is engaged on designing a new range of medium-size machinery which requires a good knowledge of general engineering practice. Suitable applicants, who should be able to work with a minimum of supervision, are invited to send personal details and salary required.—BOX No. E5693, "The Engineer." A

ENGINEERS required for work on design of machine tools, vibration studies, friction and lubrication problems, and research on the machining of metals. Good opportunities in expanding organisation for those with initiative and capability. Location in new building amid pleasant surroundings. Superannuation scheme. Send full details, including age, qualifications, experience and present salary in confidence.—BOX No. 5860, "The Engineer." A

ENGINEER required for maintenance of modern fully instrumented boiler plant; knowledge of chain grates essential. Apply, Secretary.—BOX No. E2416, "The Engineer." A

ERECTION SUPERINTENDENT

Applications are invited for the above appointment by large concern engaged in the erection of Water Tube Boilers throughout U.K. Successful candidates, with proved ability, will be required to supervise and control all aspects of progress and erection. Appointment superannuable. Salary in accordance with degree of experience and qualifications.—Applications with full particulars of age, education, qualifications and experience.—Write 0650, Wm. Porteous and Co., Glasgow.

E5809 A

ESTIMATOR required for Engineering Works in Southern England. Must be fully experienced in Structural Steelwork and Steel Fabrications. Some knowledge of Machine Shop and/or Foundry work an advantage. Pension Scheme in operation.—Write stating age, experience and salary required. —BOX No. E5853, "The Engineer." A

HAWKER SIDDELEY—INDUSTRIAL DIVISION, Brush Electrical Engineering Company Limited, Loughborough. This company has vacancies for 2 TENDERING AND CONTRACT ENGINEERS as detailed below. Preference will be given to candidates with recognised technical qualifications and applications will also be considered from Engineers who lack the necessary commercial experience but feel that given the opportunity they would enjoy this type of work. Tendering and Contract Engineer for the General Engineering Division for Industrial Electrical Applications. This is an office appointment which offers considerable scope for the exercise of initiative and in which allied experience abroad would be an advantage. Reference GE 5072. Tendering and Contract Engineer for Switchgear Division: duties will include scheme design, preparation of specifications, &c., for all classes of equipment up to 33kV. Reference: SD 5072.—Applications, which will be treated in strict confidence, should give brief personal details, particulars of training and previous experience and be addressed to the Chief Personnel Officer, Brush Electrical Engineering Company Limited, Loughborough, Leics, quoting the appropriate reference number. E5864 A

SITUATIONS VACANT

JUNIOR DETAIL DRAUGHTSMAN required for general engineering. Applicants required who have completed full apprenticeship and Army service ready for permanent position. Write, giving full particulars.—BOX No. E2384, "The Engineer." A

INSTRUMENT ENGINEER

A first class opportunity has arisen for an ENGINEER experienced in the design of electronic and/or pneumatic process control instrumentation, to join a major London Oil Refinery and Petrochemical Engineering Company.

Applicants should have at least H.N.C. with suitable endorsements.

Salary up to £1500 p.a. according to experience.

Please write giving full details in confidence to BOX No. E5811, "The Engineer."

A

MARINE ENGINEERING

THE P. & O. RESEARCH AND DEVELOPMENT COMPANY require the services of an ENGINEER with the following qualifications:

a. Honours Degree in Mechanical Engineering or equivalent.
b. Not less than five years' recent responsible and original design experience with ship's propelling machinery including Diesel Engines.
c. Age up to 50 years.

This is a technical position requiring considerable mathematical and design experience, and one having great scope for original and inventive talent.

Salary and other emoluments commensurate with qualifications.

Please reply to:

T. W. Bunyan, B.Sc., M.I.Mech.E., M.I.Mar.E.,
Director,
P. & O. Research and Development Company,
122, Leadenhall Street,
London, E.C.3.

E5851 A

MECHANICAL ENGINEER

Required by the N.C.B.'s Central Engineering Establishment at Stanhope, Bretby, Nr. Burton-on-Trent, to co-ordinate the activities of a section undertaking the development of Ancillary Equipment for an Experimental Tunnelling Machine. Applicants should have a wide experience of Engineering practice, including the development of new equipment, a good theoretical background and, if possible, a practical experience of the installation and operation of air, water and other services associated with underground machinery. A thorough understanding of problems associated with conveyors and other mechanical handling equipment is also sought. Applicants should have either a Degree in Engineering or Corporate Membership of one of the Senior Engineering Institutions associated with the appropriate training and experience. Appointment superannuable and salary according to qualifications and experience within £1250 - £1850. — Write, with full details, to Staff Dept. (X.1425/2D), National Coal Board, Hobart House, London, S.W.1, before 2nd June, 1959.

E5875 A

MECHANICAL ENGINEERING DRAUGHTSMAN, preferably holding Higher National Certificate or equivalent, experienced in textile dyeing and finishing machinery.—Applications, stating age, experience, qualifications and salary required, to the Chief Engineer, THE BRADFORD DYERS ASSOCIATION LTD., 39, Well Street, Bradford, 1. E5755 A

POWER ENGINEER REQUIRED

BORG SERVICE, a newly-formed British Company, is an independent member of a group operating throughout Western Europe with a holding company in Switzerland. This organisation specialises in the pickling of new plant in nuclear and thermal power stations and in the chemical cleaning of all types of industrial equipment. It is Europe's leading specialist in this field. The individual firms which form the group co-operate as required by interchanging technical knowledge, equipment and staff.

The British Company now requires a young, energetic Engineer who knows he has drive, initiative and ability above the average. The Engineer's duties will include technical sales and discussions, the preparation of tenders and the solution of those technical and administrative problems which face in every direction a young, rapidly growing firm.

Some experience of high pressure boilers will be required and the applicant should have held some such post as power station chemist or boiler maintenance, service or combustion engineer.

A second language and some sales experience would be an advantage. The applicant must be prepared to spend a period of training anywhere in Europe.

This position offers the utmost opportunity to a resourceful and energetic man who is capable of working on his own responsibility.

Applications, which will be treated in full confidence, should state the present salary or salary required, and should be sent within 14 days to:

BORG SERVICE INTERNATIONAL SA
Breitinger Strasse 21,
Zürich, Switzerland. E5867 A

SALES MANAGER required by an East Anglian Engineering Company. Applicants should have had a thorough Commercial training with an engineering background and must be fully competent of organising sales of capital goods in competitive home and overseas markets. Apply, giving fullest possible details.—BOX No. E5692, "The Engineer." A

BOOKS & PUBLICATIONS

PITMAN | ***TECHNICAL BOOKS***

TELEGRAPHY
By J. W. Freebody, Whit. Schol., B.Sc., etc. This new book is the successor to T. E. Herbert's *Telegraphy*—that indispensable work of reference used by engineers and telegraphists throughout the world. It is intended primarily for students and engineers but it will be of value to all engaged on the operational and traffic aspects of the subject. Fully covers the C. and G. exams. in telegraphy. 80s. net.

FACTORY ADMINISTRATION IN PRACTICE
By W. J. Hiscox and James Stirling, A.M.I.Mech.E. 7th Edition. Here is a new edition of a book that is so excellent that it had been adopted as a class textbook for students of industrial organization in educational institutions throughout the country. Recommended also by the Institute of Cost and Works Accountants. 18s. net.

ANALYSIS OF PIPE STRUCTURES FOR FLEXIBILITY
By John Gascoyne, A.F.Inst.Pet. A new book for piping designers and designer-draughtsmen which deals with specialized piping design for high-temperature and high-pressure use where the ordinary procedures do not apply. This has particular application to petroleum refineries, petro-chemical and other chemical industries, feed systems for electricity and nuclear power stations, etc. 45s. net.

FROM ALL BOOKSELLERS | **Parker St., Kingsway, London, W.C.2**

HMSO

Effect of a Surface-Active Medium on the Deformation of Metals

by V. I. LIKHTMAN, P. A. REBINDER and G. V. KARPENKO

The latest addition to the current series of translated Russian technical books issued by the Department of Scientific and Industrial Research. It contains information on a new field of research into the effects of environment, in particular liquid surface active media, on the mechanical properties of metals. Illustrated.

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SITUATIONS VACANT

PROJECT ENGINEER

An internationally-known engineering Group of Companies in the Chemical and Oil Refinery, Contracting industry require a first-class man for liaison with clients and co-ordination of specialist design groups on large-scale projects.

Applicants, aged up to 40, should already hold a similar position. Essential qualifications are A.M.I.Chem.E. or A.M.I.Mech.E.

Commencing salary in the region of £1750 p.a. Our staff have been advised of this vacancy. Please write in confidence.—BOX No. E5891, "The Engineer."

A

PROJECT MANAGER

An important Company engaged in the Design, Procurement and Construction of Major Chemical and Oil Refinery Plants require a senior man to take control of large projects.

Applicants should already hold a similar position and be suitably qualified. Salary open to discussion but in the region of £3000 p.a. Normal benefits of a well-established and stable Company.

All enquiries will be treated confidentially. Our staff have been informed of this vacancy. Write full particulars.—BOX No. E5890, "The Engineer."

A

SENIOR DRAUGHTSMAN required for Design Office. Work is of Electro-Mechanical nature and duties would include specification writing to Government contract requirements. Knowledge of modification procedure an advantage.—Apply, stating age and salary required, to S. G. BROWN LIMITED, Shakespeare Street, Watford, Herts. E2388 A

STRUCTURAL DESIGNER/DETAILERS R.C. with at least 5 years' experience, required by Consulting Engineers engaged on interesting and varied work. Good prospects. Commencing salary up to £1000 p.a.—BOX No. E5833, "The Engineer." A

TECHNICAL SALES REPRESENTATIVE

A vacancy occurs in the Manchester Office of a Clydeside Firm engaged in the manufacture of Auxiliary Machinery. Applications are invited from men between 25 and 35 years of age, with good personality and a capacity for original creative thinking. To be Apprentice-trained and hold H.N.C. or equivalent. Duties will be concerned with Market problems and technical representation within a prescribed area. A comprehensive training will be given prior to assuming responsibilities. The position offers excellent prospects with a progressive salary scale and there is a Superannuation Scheme in operation.—Write, 1553 Wm. Porteous and Co., Glasgow.

E5893 A

STRUCTURAL ENGINEER, QUALIFIED, required for Consultants' office. Must have had experience in running a team engaged on a varied range of structures. Commencing salary up to £1300 p.a.—BOX No. E5834, "The Engineer." A

STRUCTURAL STEELWORK DESIGNER with a good knowledge of light structures as well as conventional steel design required by Consulting Engineers. Five-day week. Pension Scheme; holiday arrangements honoured.—Apply stating full details of experience and salary required to BOX No. E2407, "The Engineer." A

TECHNICAL ESTIMATOR required in Pump Division of an old-established Engineering Company, Birmingham area. Experience in tendering for centrifugal refinery process pumps and chemical pumps for the Oil Industry and Chemical Trades essential. Contributory pension scheme, five-day week, canteen and recreational facilities.—Apply, giving full details of training, qualifications, past employment and salary range, in strict confidence, to the Secretary, TANGYES LIMITED, Cornwall Works, Smethwick. E5761 A

TEST HOUSE ENGINEER required for organising and running of test house in established diesel manufacturing company in East Anglia. Applicant should have first-class knowledge of test bed procedure and should also be a fully experienced electrical engineer. Ability and personality to organise and take full responsibility for testing programmes. University or H.N.C. qualifications an advantage. Good salary will be paid to the right man.—Applications, in writing, stating age, qualifications and experience, to Labour Officer, BOX TH 669, A.K. Advg., 212a, Shaftesbury Avenue, London, W.C.2. E5884 A

VACANCY FOR MAN FOR GENERAL TRACTOR REPAIRS, &c., and to run Cold Storage Plant. Modern house on Farm.—Apply: THE GROVE FARMS (HARWELL) LTD., Woodlands, Milton Hill, Nr. Abingdon, Berks. E5742 A

WANTED.—SENIOR JIG AND TOOL DRAUGHTSMAN and MACHINE TOOL DRAUGHTSMAN, by company in the South Coast Area. Experience in machining light alloys and knowledge of hydraulics and pneumatics an advantage. Write, stating age, details of experience, qualifications and salary required.—BOX No. E5870, "The Engineer." A

WANTED.—PRODUCTION ENGINEER required for Engineering Department of a company situated in the South Coast area, manufacturing specialised components for the motor industry. Wide experience of production engineering essential. Some knowledge of time and motion study and works planning an advantage. Write, giving age, details of experience, qualifications and salary required.—BOX No. E5871, "The Engineer." A

WORKS MANAGER to take charge of works in Glasgow district manufacturing steam turbines up to 15,000kW. and all related gear. Good prospects, salary up to £2500, bonus and superannuation. Candidates should preferably hold a Degree but must have successfully held a similar position in a precision engineering works.—BOX No. E2417, "The Engineer." A

SALES REPRESENTATIVES

A very old-established firm of Engineers and Gear Specialists requires SALES REPRESENTATIVES having an established connection amongst Buyers of Medium and Medium/Heavy Plant, e.g. Steelworks, Shipyards, Mines, &c. Applicants, who should have some technical knowledge, are asked to submit full details, stating experience, area covered and salary expected. The firm's own staff have been informed of this advertisement.—BOX No. E5819, "The Engineer."

A

ELECTRICAL ENGINEER

wanted by leading German manufacturer for German-English translations. Applications are invited from British-trained engineers with a good general education and sound technical training, preferably also with practical experience in the application of electric equipment. Good working knowledge of German is essential. The ability to write clearly and concisely will be expected of candidates. A five-day week is worked, with generous holidays. Favourable housing conditions for permanent staff. Apply, stating age, education, qualifications, experience and salary required, to BOX No. E5790, "The Engineer."

A

POWER RECTIFIER DESIGN

(*a*) ENGINEERS. Due to expanding business, a large electrical manufacturing firm in the Midlands requires Assistant Design Engineers for rectifier work. Previous rectifier experience not essential, but applicants should have degree (electrical) or equivalent, and some practical training. Work involves mercury arc and semi-conductor rectifiers and application engineering of all kinds, with scope for wide experience and interest; good salary and prospects. Pleasant residential area, ample housing, excellent educational facilities.

(*b*) DRAUGHTSMEN also required for same business. Must have previous experience electrical apparatus.

Apply, with full particulars, to BOX No. E5689, "The Engineer."

A

Classified Advts. continued on page 122

SITUATIONS VACANT

JOHN SUMMERS & SONS Limited

SHOTTON · CHESTER

invite applications for the following vacancies in the Engineering Department at Hawarden Bridge Steelworks.

SENIOR MECHANICAL ENGINEER

to take technical and administrative charge of the Rolling Mills Engineering Department, responsible for Ingot stripping and charging Soaking Pits, Slabbing Mill, Hot and Cold Continuous Strip Mills, Pickle Lines, Temper Mills, Annealing Plant, Finishing equipment, Cranes, Services, Roll Grinding and Machine Shop, etc.
Age 35-50. Degree or H.N.C. and previous experience in Heavy Engineering essential.

BUILDING DEPARTMENT MANAGER

to take charge of the existing Building Department covering the whole of Hawarden Bridge Steelworks (other than New Construction).
Experience in domestic types of construction, roads and drainage, rather than in mass reinforced concrete dams and harbours is essential. Knowledge of refractory work desirable. Trades include Joiners, Bricksetters, Plumbers, Painters and Decorators, Plasterers, Sheeters, Riggers and Rough Painters, Gardeners, Office Cleaners and General Labour force.
Age 35-50. Administrative and practical experience of equivalent magnitude in the Building industry essential.

PRODUCTION ENGINEER

to be responsible within the General Engineering Department for scheduling and Production planning in the Centralised Machine and Assembly Shops of the Company. Candidates with previous experience in heavy Engineering preferred.
Age 30-45. H.N.C. or similar qualification required.

ASSISTANT MECHANICAL ENGINEER

to be responsible to the Plant Engineer in charge of a Department of the factory carrying out the following operations : Cold Rolling of Steel Sheet, Annealing, Galvanising, Specialised Sheet Finishing ; Cranes, Services, Machine Shop and Stores.
Age 30-45. H.N.C. or equivalent qualifications required.
Promotion prospects good for the right candidate.

Replies *in confidence* to :

JOHN SUMMERS & SONS LTD.
SHOTTON · CHESTER
under ref. R.L.W./ENG.

E5876 A

SITUATIONS VACANT

DRAUGHTSMAN

UNILEVER LIMITED, at their Food Research Department near Bedford, require a Draughtsman in the Development Division, to work on the design of special purpose machinery and of Pilot Plant equipment in connection with the food industry. Candidates must have served a full engineering apprenticeship and possess a good Higher National Certificate. The preferred candidate will be about 25 years of age and have completed National Service commitments.

Salary will be paid according to age and experience and there is a comprehensive superannuation scheme.

Please apply to : The Staff Officer (IDM.71), Unilever Limited, Colworth House, Sharnbrook, Bedford.

E5849 A

DESIGNER-DRAUGHTSMEN

REQUIRED URGENTLY BY

KELLOGG

INTERNATIONAL CORPORATION

(SENIOR STRUCTURAL (STEEL), ARCHITECTURAL, ELECTRICAL)

Designer-draughtsmen of the above categories are cordially invited to contact us with a view to permanent employment. Candidates must hold Higher National Certificate or equivalent plus five to seven years' design experience. Successful applicants will benefit from excellent salaries, first class working conditions, attractive personnel benefits and every opportunity for promotion. Apply to Personnel Manager,

KELLOGG INTERNATIONAL CORPORATION
7-10, CHANDOS STREET, CAVENDISH SQUARE, LONDON, W.1.
Tel.: MUSeum 4010 (Please quote reference 139/G)

E5873 A

ENGINEER

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE.

To be responsible for the engineering design of electronic and electro-mechanical equipment to suit production and service requirements on the basis of information supplied by the Research and Development laboratories ; and to be responsible for the early stages of production.

A recognised engineering apprenticeship is required and either Corporate Membership of the Institution of Mechanical or Electrical Engineers or equivalent qualifications. Previous experience in this type of work is desirable.

SALARY : Will be assessed within the range £845–£1800 according to qualifications and experience.

Contributory Superannuation Scheme. A house or substantial assistance with house purchase will become available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at above address. Please quote ref. 2246/25.

E5835 A

WATER-TUBE BOILER PLANT DESIGN

STAFF VACANCIES

(*a*) Senior and Junior Design Engineers for Proposal and Contract work on Water-Tube Boiler Plant. Previous experience on Water-Tube Boiler design preferable but not absolutely essential. Minimum qualifications are an engineering degree and/or A.M.I.Mech.E., while starting salary will be in the range £650 to £1150 p.a., dependent upon qualifications and experience. The work is interesting and varied and covers a wide field of heat-transfer applications.

(*b*) Proposal Draughtsman for interesting work on complete Water-Tube Boiler installations. Applicants should have some previous experience on Water-Tube Boiler Construction and layout. Salary according to experience but not less than £15 per week.

Five-day week, Pension Scheme. Staff Dining Room.

Write, Staff Manager,
FOSTER WHEELER, LTD.,
3, Ixworth Place,
London, S.W.3. E5782 A

The world's leading inventors and manufacturers of special purpose precision machinery for the Tobacco Industry have opening in their London Drawing Offices for :—

TECHNICAL AUTHOR

to assist in the compilation of operating and maintenance instruction manuals dealing with the Company's machinery. For this interesting and progressive pensionable staff position the requirement is for a suitably qualified Mechanical and/or Electrical Engineer already practised in the art of technical writing. Applications stating age (which should not be over 45), qualifications and experience should be personally addressed in confidence to G. B. Salmon,

MOLINS MACHINE CO. LTD.,
Evelyn Street, London, S.E.8

E5863 A

SITUATIONS VACANT

JOHNSON, MATTHEY & CO., LIMITED,

DESIGN ENGINEER

Aged 23/33, with good drawing-office experience, is required for a Chief Mechanical Engineer's office in Central London. A sound practical training and knowledge of engineering services is essential.

The work entails handling projects from the drawing-board through to construction and running in for production.

Conditions of service include free lunches and an annual bonus, also a contributory pension scheme. Salary according to age, qualifications and experience.

Write, giving full details of age, qualifications, experience, &c., to the Secretary, Johnson, Matthey & Co., Limited, 78, Hatton Garden, London, E.C.1.

E5738 A

SITUATIONS VACANT

MOUNT ISA MINES LIMITED, QUEENSLAND, AUSTRALIA

Vacancies for

JUNIOR MECHANICAL ENGINEERS

(Single Men)

Qualifications : B.Sc. in Mechanical Engineering.

Duties : Technical Assistant to Senior Engineers.

Salary : £A1300 per annum for new University Graduates. £A1360 for graduates with one year's experience. In addition to salary, successful applicants will receive variable Lead Bonus with a Minimum of £A5 per week and a Maximum of £A17 5s. per week.

Applications : Stating age and details of qualifications and experience to :—

London Secretary,
Mount Isa Mines Limited,
Adelaide House,
King William Street, London, E.C.4

E5776 A

SITUATIONS VACANT

THE BAHRAIN PETROLEUM COMPANY LIMITED

VACANCIES FOR

CHEMICAL AND MECHANICAL DESIGN ENGINEERS

Applicants for these positions in Bahrain should have a Degree in CHEMICAL or MECHANICAL ENGINEERING, with a minimum of four years' subsequent experience covering design problems associated with liquid and gas pumping equipment, gas engines, steam turbines, heat exchangers, coolers, steam generators and boilers, piping systems, high and low pressure process units, together with the necessary calculations of flows, pressure drops, heat transfer factors and the like.

The commencing salary would depend on qualifications and experience, with a minimum of £1600 : 0 : 0 per annum, in addition to which free air-conditioned accommodation and a living allowance are provided. An initial kit allowance, medical attention, paid home and local leaves are also provided, with passage paid for the former and generous assistance towards fare for latter.

Apply in writing, with full particulars, to Caltex Services Limited, Caltex House, Knightsbridge Green, London, S.W.1, quoting " ENG." E5772 A

WORKS ENGINEER

Well-known English Company, having formed an associated Iranian Company, are looking for a Works Engineer to take full technical control of a factory in Tehran which will be producing consumer goods in the light engineering field. Experience in all or most of the following processes is essential :— Press work up to 150 tons, spray painting, electroplating, vitreous enamelling, spot welding, soldering, inspection and assembly.

The successful applicant must be prepared to live in Tehran and will be employed by the Iranian Company. A good salary will be paid to the right man, and the initial engagement will be for a term of four years : a further term, or a permanent engagement, will be considered at the end of this period.

Write in confidence, giving fullest particulars, to BOX No. E5889, " The Engineer."

A

The world's leading inventors and manufacturers of special purpose precision machinery for the Tobacco Industry have opening in their London Drawing Offices for :—

MECHANICAL DESIGNER

Applicant should be qualified Engineer, preferred age 25-40, of sound practical experience and with original and inventive mind, receiving recognition in his present post on that account.

This opportunity is permanent and progressive and holds promise of absorbing work on most attractive terms. Applications stating age, qualifications and experience should be personally addressed in confidence to G. B. Salmon,

MOLINS MACHINE CO. LTD.,
Evelyn Street, London, S.E.8

E5862 A

UNILEVER

have vacancies for

INSTRUMENT ENGINEERS

Applicants should have adequate academic or professional qualifications in electrical engineering or physics and should have design experience in electronics, process control or instrumentation.

INSTRUMENT TECHNICIANS

Applicants should have experience in the commissioning and servicing of instruments and process control equipment.

Applications giving details of training, qualifications and experience should be addressed to Head Office Staff Department (WF 40), Unilever House, Blackfriars, London, E.C.4.

E5789 A

BRITISH OXYGEN ENGINEERING LIMITED

invite applications from

DEVELOPMENT ENGINEERS

to join a team engaged in development work on Plants operating at Low Temperature.

This new field of endeavour offers considerable scope to engineers with a good degree or equivalent and who have experience in the design of various types of compressors, heat exchangers and pressure vessels.

The Company offers excellent conditions of service and pursues a progressive salary policy. Assistance with housing may also be given.

Applications in writing, giving age, qualifications, experience and present salary, should be addressed to:—

Employment Officer (E/G 4558),
BRITISH OXYGEN ENGINEERING LIMITED,
Angel Road, Edmonton, N.18.

E5883 A

DEVELOPMENT ENGINEER

Our Company, which occupies a leading position in the chocolate and confectionery industry, employs over 10,000 people in an extensive and well-equipped works on the outskirts of York. We have a large Engineering Division whose staff is constantly working on the development and installation of new machinery to meet the requirements of a highly-competitive industry, where a high standard of quality and efficiency are all-important.

We have a vacancy for a young Mechanical Engineer, for development work on plant and manufacturing processes. The post will be concerned with design, development, installation and commissioning of food processing machinery, air conditioning and refrigeration plant, mechanical and bulk handling schemes (including automatic controls), mechanisation of existing processes, &c.

Applicants, who must have a good technical education and preferably a university degree, should write for our official application form to :

The Staff Officer (Men),
ROWNTREE & CO. LTD.
The Cocoa Works, York.

E5879 A

SITUATIONS WANTED

AIR CONDITIONING Executive Engineer, British, qualified, age 32, fluent German, present capacity General Manager leading American air conditioning and refrigeration distributorship in Caribbean area. Desirous to relocate U.S., Continent or U.K., with high-grade manufacturer. 4 years' executive experience, responsible only to Board of Directors for Management, Sales, Contracts, Estimates, Buying, Installation, Design and Company's operation. Total of 11 years in engineering industry. Best references on mutual interest.— BOX No. E2419, " The Engineer." B

GRADUATE ENGINEER (Hons.), Apprentice Trained, Assoc.M.I.Mech.E., A.M.I.Prod.E., A.F.R.Ae.Soc., A.M.I.I.A., A.C.W.A., Diploma in Metallurgy. Experience in precision, light and medium engineering, batch and jobbing, electrical, hydraulics, engines, sheet metal and plating, foundry, &c., in all spheres, including design, production, sales and overseas. Present post General Works Manager, previously Consultant, Works Manager, Production Engineer, Quality Engineer, Works Superintendent with federated and non-federation firms. Age 48, requires top level post as Works, Production or Managing Director to Public or Private Company.— BOX No. E2418, " The Engineer." B

Classified Advts. continued on page 124

BUSINESSES & PREMISES

HALLAM STREET, W.1. 2 Offices (235 sq. ft. and 165 sq. ft.), and toilet on 2nd floor, to be Let on short term, either separately or together. Rent £450 p.a., including rates, c.h. gas, electricity, staircase lighting and cleaning. Telephone service available if required.—Fineman, Lever and Co., 8/10, Hallam Street, W.1 (LAN 0561). E2414 L

BARNET, Herts, 7500 sq. ft. self-contained Ground Floor Factory with services and central heating. Large yard and good loading facilities. To be Let on lease.—Chamberlain and Willows, 23, Moorgate, E.C.2 (MET.8001). E5869 L

BUSINESS OPPORTUNITIES

BELGIAN METALLURGIC FACTORY of middle importance wants to enter into connection with British firms desirous to collaborate or to take an interest in manufacturing material in European Common Market. Write to Journal.—BOX No. E5750, "The Engineer." O

THE REPRESENTATIVE of a progressive New Zealand Engineering Company with full and extensive range of manufacturing facilities, will be visiting this country between May and August. He is keen to discuss with British and Continental manufacturers arrangements for making their products in New Zealand under licence or on a royalty basis.—BOX No. E2398, "The Engineer." O

REMPLOY SPONSORSHIP SCHEME.—Send for details which show an attractive proposition to manufacturers.—Write to the Managing Director, Remploy, Ltd., 25–28, Buckingham Gate, S.W.1 or telephone VICtoria 6621 (12 lines). E155 O

GRINDING WHEEL MANUFACTURERS—Belgian—desirous appointing STOCKIST-DISTRIBUTORS on commission basis in following areas. Glasgow, Newcastle, Manchester, Birmingham, London. Write in confidence, stating facilities available, experience, proposed terms.—Chambers, 4, Blomfield Street, London, E.C.2. E2383 O

MISCELLANEOUS

TIME RECORDERS, Sales, Rentals, Service, Telephone Hop 2239.—Time Recorder Supply and Maintenance Co., Ltd., 157–159, Borough High Street, London, S.E.1. E110 I

FOR HIRE

LATTICE STEEL. Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. ('Phone, SLOane 5259). E103 K

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process; sample castings treated; A.I.D. approved.—Recupero Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone: Knottingley 2743/4). E116 MW

MACHINERY Etc. WANTED

SECONDHAND HEALD 72A 5 INTERNAL GRINDER.—BOX No. E5858, "The Engineer." F

FOR SALE

FOR SALE OR HIRE

Butters 10-ton Electric Derrick Crane, 120ft. jib. 2-motor type. New 1955. Complete with 25ft. Towers and Bogies.

Fowler 150 h.p. 0–4–0 Diesel Locomotive, 4ft. 8½in. gauge. Fully reconditioned.

ABELSON AND CO. (ENGINEERS), LTD.,
Coventry Road, Sheldon, Birmingham, 26.
'Phone: Sheldon 2424. E5894 G

600

ECONOMIC BOILERS

Two DANIEL ADAMSON horiz. double-pass, 10ft. 6in. dia. by 16ft. by 20ft. 8in., excluding smokebox. Evap. 14,400 lb./hr., 160 p.s.i. With feed pumps, chimney, grit arrestors, induced draught fans. Ideal for oil-firing.

GEORGE COHEN,

SONS AND CO. LTD.
WOOD LANE, LONDON, W.12.
(Shepherds Bush 2070)
STANNINGLEY, Nr. LEEDS.
(Pudsey 2241). E200 G

FOR SALE

FOR SALE

GOOD REUSABLE B.H. AND F.B. RAILS, as follows:—
440 tons 85 lb. approx. B.H. Rails, 60ft. lengths.
116 tons 85 lb. approx. B.H. Rails, 45ft. lengths.
62 tons 90 lb. approx. B.H. Rails, 26ft. lengths.
271 tons 79 lb. approx. F.B. Rails, 26ft. lengths.

Further details, Rubbings, &c., on application. Attractive prices.

COX & DANKS, LTD.,
FREDERICK ROAD,
MANCHESTER, 6.
Telephone: Pen 2481. E5792 G

FRED WATKINS

(ENGINEERING) LTD.

Fielding 800-ton Indenting Hydraulic Press, platens 5ft. 4in. by 4ft. 4in. and 5ft. 1½in. by 4ft. 1½in., with pump and motor.

Fielding 500-ton Vertical Downstroke Hydraulic Press, 42in. by 36in. platens, with pumps and motors.

Fielding 200-ton ditto, 3ft. stroke, with pumps and motors (5 available).

Fielding 100-ton ditto, 4ft. to 5ft. stroke, with pumps and motors.

Two 73ft. 4in. by 5ft. Kilns or Dryers, with Crofts Reduction Gear and 27 h.p. motor.

Two 26ft. by 4ft. Rotary Cooler or Dryers, with reduction gear and motor.

Available at low prices ex present sites to save cost of bringing into stock.

FRED WATKINS (ENGINEERING) LTD.,
COLEFORD, GLOS. E151 G

FOR SALE

RAILWAY TURNTABLE
For Sale.—Mundt type standard gauge turntable, 65ft. long, carrying capacity 150 tons approx.

WATER CRANE
3000 gallon water crane.

TURNOUTS
Twenty 1 in 8 turnouts in 75 lb. F.B. rail; interchangeable to suit L.H. or R.H.

All these items are in excellent condition.

Apply: EAGRE CONSTRUCTION CO., LTD., East Common Lane, Scunthorpe, Linca. ('Phone: 4513). E150 G

FOR SALE

NEW MITCHELL 16½IN. CENTRE BY 24FT. GAP BED LATHE

admit 17ft. 3in. between centres; swing 61in. by 18½in. in gap; 4½in. hollow spindle.
Immediate delivery.

F. J. EDWARDS LTD.,
359–361, EUSTON ROAD,
LONDON, N.W.1.
Phone: EUSton 4681 and 3771.

E5836 G

FOR SALE

One 1942 Precimax M.P.M. Type 8/24 Plain Cylindrical Grinder, hydraulically operated, provision for Precizer, with suds equipment and electrics, 400/440 volt, 3 phase, 50 cycle supply.

One 1912 Asquith 7ft. Radial Drill Column and Arm only (no base plate). Main and auxiliary spindles both fitted with No. 5 Morse Taper. Complete with motor and control gear, suitable for 220 volt D.C. supply.

One 1955 Morgan Oil-Fired Bale-out Furnace, complete with blast fan and air flow indicator, also spare crucible. Capacity, 200 lb. of aluminium.

Offers invited.—Reply to Ref. CB/1, Crompton Parkinson (Chelmsford), Ltd., Chelmsford, Essex (Tel. 3161). E5880 G

ONE 10-TON ELECTRIC LUFFING AND TRAVELLING JIB CRANE by Cowans, Sheldon and Co., Ltd. 50ft., maximum radius of jib, maximum lift above rail level 45ft., motorised 230 volts d.c.

JOHN CASHMORE, LTD.,
NEWPORT, MON. E154 G

PLANT FOR SALE

Coles A.E.C. Lorry-mounted Mobile Crane fitted with 40ft. jib. Excellent condition. £2500. C.P., Ltd., Crown Works, Southbury Road, Enfield. E5892 G

COMPLETE ECONOMIC BOILER PLANT. Including 3 Penman Boilers, each 10,000 lbs./hour, 150 lbs. w.p. Complete with Chain Grate Stokers, Coal Elevators, Feed Pumps, Fans, Economisers, Dust Collectors, Soot Blowers, &c. New 1941. Excellent condition. Full specification on request.—Apply BOX No. E5857, "The Engineer." G

FOR SALE

SERVICE EDWARDS VALUE!

NEW STOELTING Pyramid Type Plate Bending Roller, motorised 400/440/3/50, capacity 10ft. wide by ½in. mild steel, diameter of rollers, top, 9½in.; bottom, 7½in., drop end bearing for removal of completed cylinders, support rollers to bottom rolls, reduction gearbox drive to bottom rolls with multi-disc slipping clutches. Motorised adjustment to top roller.

RUSHWORTH Double-Geared Open-Ended Power Guillotine, overcrank type, fitted with automatic sheet hold-down and adjustable front, back and side gauges, arranged motor drive for 380/440/3/50, capacity mild steel 4ft. by ¼in., gap in open ends 6¾in.

NEW BESCO 8ft. 4in. by ⅛in. Type HK. All Steel Undercrank Open-Ended Production Power Guillotine of all steel construction, arranged motor drive for 400/440/3/50, length of blades 110½in., capacity ⅛in., gap in side frames 3½in., strokes per minute 54.

CRAIG & DONALD Model 400/10, All Steel Motorised Double-Geared Press Brake of steel plate construction, arranged motor drive for 440/3/50, pressure exerted 400 tons, former capacity 10ft. by ½in., depth of gap 12in., width between side frames 82in., stroke approximately 4in., weight approximately 29 tons.

BESCO No. 21 size Inclinable Power Press, treadle operated non-repeat clutch, ram fitted with knock-out, fitted with detachable tie bars, standard stroke 3in., centre to back 9½in., bed 27in. by 18in., hole in bed 11½in. by 12in., can be supplied for belt drive or self-contained motor drive.

ROBERTSON Motorised Geared Section Rolling Machine, at present fitted with rollers for forming 2½in. by 2½in. angle sections, diameter of roll shafts 2½in., width between bearings 16½in., working centres adjustable up to 7½in., 14 rollers arranged in 7 pairs, arranged motor drive for 400/440/3/50.

Photographs of the above are available.

Very favourable Hire Purchase terms can be obtained.

MACHINE TOOLS, NEW AND USED,
Of Every Description. Attractive Prices.

F. J. EDWARDS LTD.,

359–361, EUSTON ROAD,
LONDON, N.W.1.
Telephone: EUSton 4681–3771,
and at
LANSDOWNE HOUSE, 41, WATER STREET,
BIRMINGHAM, 3.
Telephone: Central 7606–8. E207 G

HYDRAULIC FORMING AND FORGING PRESSES

3000-ton Down-stroke PRESS for HEAVY PLATE FORMING AND BENDING, 3 rams; admitting 10ft. 6in. between columns; bed 16ft. by 8ft.

2000-ton Down-stroke FORGING PRESS, 5ft. stroke; bed 8ft. 6in. by 8ft.; daylight 11ft.

1000-ton Down-stroke FORGING PRESS by Wellman, bed 7ft. by 6ft.; daylight 9ft.

475-ton FLANGING PRESS by Hugh Smith, table 10ft. dia., 4 vice rams.

REED BROTHERS (ENGINEERING) LTD.,
Replant Works,
Woolwich Industrial Estate,
London, S.E.18.
Telephone: Woolwich 7611/6
E5700 G

TURBO-GENERATOR FOR SALE by Metropolitan-Vickers, 780kW., 230 volts D.C., 7500 r.p.m., complete with reduction gear box, compact condensing plant and spare armature. Good condition throughout.—Write for full particulars, R. S. HAYES LIMITED, Bridgend, Glamorgan. Tel. Bridgend 1311 (3 lines). E5770 G

CALCIUM SILICIDE.—Finely ground CALCIUM SILICIDE—for nodular iron, exothermic compositions, etc. (now being successfully used by several foundries) at prices which save you money.—TOXANE, LTD., 47, High Street, Edgware, Middlesex. EDGware 6666. E2412 G

FOR SALE

600

ALTERNATOR SETS

UNUSED 979kVA, 6·6kV, 3-phase, 50 cycles DIESEL ENGINE DRIVEN ALTERNATOR SET incorporating engine by Mirrlees, Bickerton and Day, type JV.16; 16-cylinder, speed 750 r.p.m., developing 1120 h.p. Direct coupled to alternator by Brush Electrical revolving field, mounted on soleplates with direct coupled exciter. Engine complete with standard ancillaries, alternator with switchboard by Reyrolle with automatic voltage regulator.

500kW, continuous 24-hour duty, 380/400 volts, 3-phase, 50 cycles DIESEL ENGINE DRIVEN ALTERNATOR SET, direct coupled at 375 r.p.m. and comprising 750 h.p. Belliss and Morcom 7-cylinder vertical engine, complete with ancillaries, starting equipment. Direct coupled to alternator by Lancashire Dynamo Company, complete with switchgear.

TWO 1000kW, 3·3kV, 3-phase, 50 cycles back pressure type STEAM TURBO ALTERNATOR SETS each incorporating turbine by Belliss and Morcom, speed 4500 r.p.m., steam pressure 195 p.s.i., 380 deg. Fah. temperature, exhausting against 15 lb. back pressure. Direct coupled through David Brown gearbox ratio 4·5 : 1 to alternator by Harland Engineering Company with direct coupled exciter. Each complete set mounted on cast iron baseplate and complete with switchgear with automatic voltage regulator, also hand-operated overhead crane.

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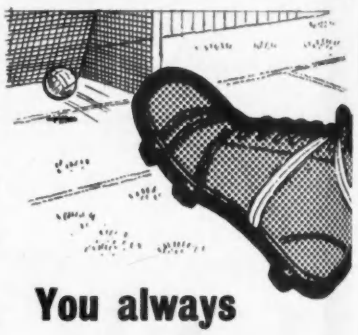

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SALES BY AUCTION

		Main Location	*Auctioneers*
May 26	Vehicles and miscellaneous stores.	M.O.S. Storage Depot, Bowhouse, Hurlford, Nr. Kilmarnock.	DIXON & WALLACE, LTD. (Dept. L), Bank Buildings, Graham Square, Glasgow, E.1. (Tel.: Bridgeton 2447.)
May 29	Miscellaneous stores, including greatcoats, pullovers, kit-bags, tool kits, &c.	Command Ordnance Depot, Coypool, Marsh Mills, Plymouth. (Sale at Kinterbury House.)	WOOLLAND, SON & MANICO (Dept. L), Kinterbury House, St. Andrews Cross, Plymouth. (Tel.: 65356.)
June 2–5	Vehicles, lifting and earth moving equipment, etc., including:	M.O.S. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)

Morris Minors, Ford Anglias and Populars and other saloon cars, Jeeps, Land Rovers, Mack tractors, utilities, light and heavy trucks, vans, tippers, coaches, dual purpose vehicles (many fitted with diesel engines), tankers, trailers, Koehring "304A" excavators, rome rigged dragline, face shovel or crane, Smith Rodley excavator, Iowa crusher, 32 mobile cranes by Coles, Hyster, Jones, Lorain and other makers, tractors, bulldozers, angledozers, road rollers, fork lift trucks, dumpers, tar boilers and heaters, deepwell pumps, Caterpillar track assemblies, track presses, Chaseside high-lift shovels, 330 solo and combination motor cycles, tyres, etc.

June 3	Miscellaneous stores.	Northern Command Ordnance Sub Depot, Barlow, Nr. Selby, Yorkshire.	BARTLE & SON (Dept. L), 50–52, Merrion Street Leeds, 2. (Tel.: 2.0898.)
June 10	Machine tools and miscellaneous stores.	Technical Stores Depot, Old Dalby, Leics. (Sale at Melton Mowbray.)	SHOULER & SON (Dept. L), 1, Norman St., Melton Mowbray, Leics. (Tel.: 3081.)
June 16	Machine tools and miscellaneous stores.	M.O.S. Storage Depot, Byley, Nr. Middlewich, Cheshire. (Sale at New Islington Public Hall, Ancoats, Manchester.)	J. H. NORRIS & SON (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
June 19	Miscellaneous stores.	Returned Stores Group, Reed Hall, Colchester, Essex.	FENN, WRIGHT & CO. (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.)
June 25–26	Machine tools and miscellaneous stores.	Hawker Aircraft Factory, South Shore, Blackpool.	LESLIE A. BUTSON (Dept. L), 16, Birley Street, Blackpool. (Tel.: 21073.)
June 30–July 2	Machine tools and miscellaneous stores.	M.O.S. Storage Depot, Royal Arsenal, Woolwich, S.E.18.	FULLER, HORSEY, SONS & CASSELL (Dept. L), 10, Lloyd's Avenue, E.C.3. (Tel.: Royal 4861.)

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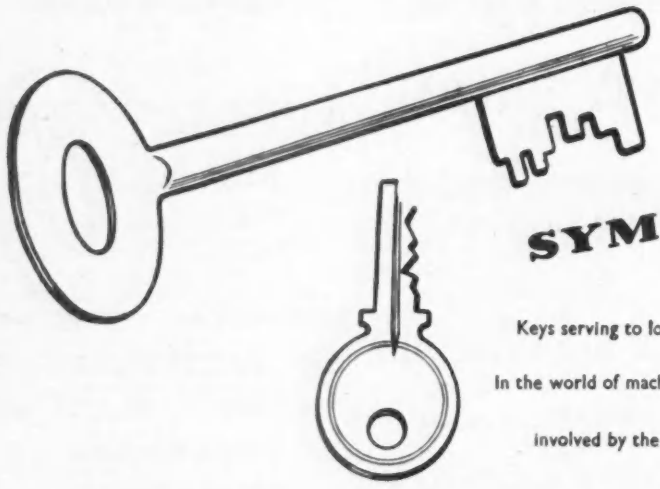

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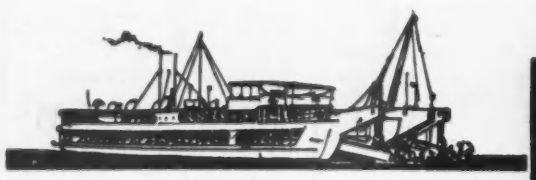

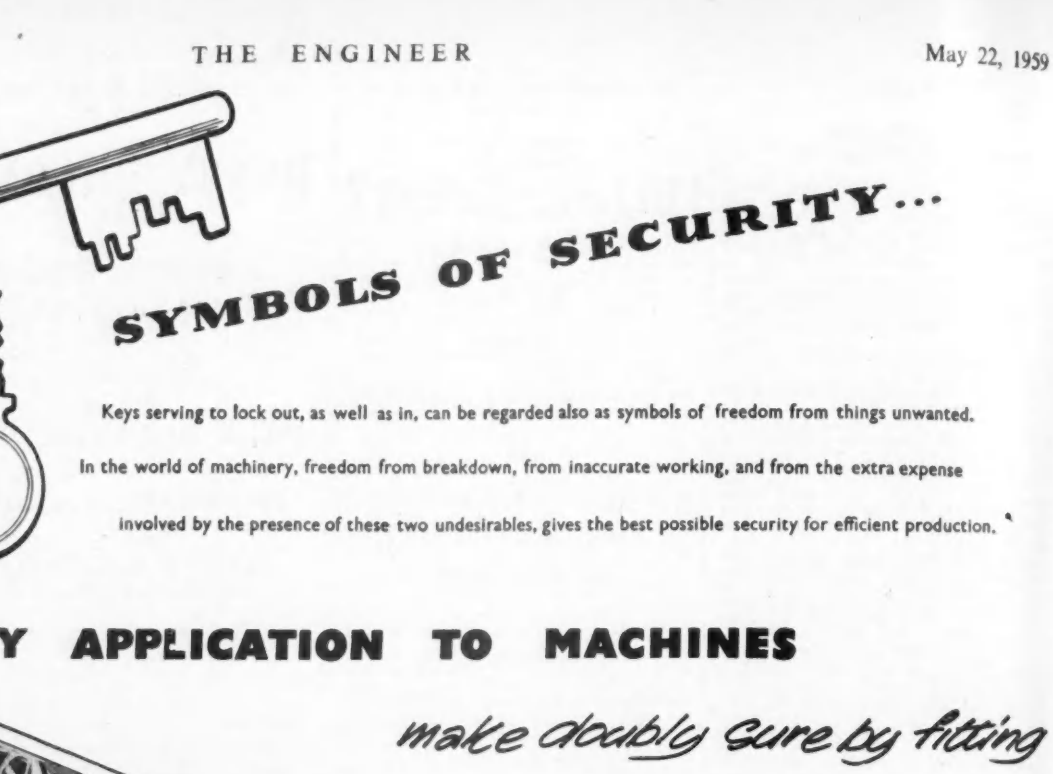

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INDEX TO ADVERTISERS

PAGE

Aabacas Engineering Co., Ltd. 4
Abbott & Co. (Newark), Ltd. 47
Adamson, J., & Co., Ltd. 38
Air Control Installations, Ltd. 73
Aiton & Co., Ltd. 100
Albion Engineering Co., Ltd. 50
Albright & Wilson (Mfg.), Ltd. 35
Allen, W. H., Sons & Co., Ltd. 72
Anderson, C. F., & Son, Ltd. 29
Appleby-Frodingham Steel Co. 99
Arc Manufacturing Co., Ltd. 79
Arup & Arup, Ltd. 59
Ash, J., & Son, Ltd. 21
Ashmore, Benson, Pease & Co. 9
Ashworth Ross & Co., Ltd. 50
Associated Electrical Industries, Ltd. 78
Audley Engineering Co., Ltd. 68
Automation, Ltd. 24
Automotive Products Co., Ltd. 117

B.R.C. Engineering Co. 86
Bailey, Sir W. H., & Co., Ltd. 93
Baker, P. W., & Sons (Sales), Ltd. 22
Barron, W. S., & Son, Ltd. 36
Beecham Buildings, Ltd. 4
Benton & Stone, Ltd. 111
Birmingham & Blackburn Construction Co., Ltd. 70
Blackwell Bearings, Ltd. 82
Booth, J., & Bros. 74
Boulton, W., Ltd. 80
Boulton Paul Aircraft, Ltd. 93
Bristol Siddeley Engines, Ltd. 26-104
British Aluminium Co., Ltd. 95
British Appliances Mfg. Co., Ltd. 34
British Industrial Engineering Co. (Staffs.), Ltd. 89
British Ropeway Engineering Co., Ltd. 49
British Steam Specialties, Ltd. 62
Britool Service Tools 80
Bronx Engineering Co., Ltd. 61
Brookes & Adams, Ltd. 62
Broom & Wade, Ltd. 56
Brown, D., Corporation (Sales), Ltd. 46
Brown, N. C., Ltd. 15

PAGE

Brownlie & Murray, Ltd. 106
Bruce Peebles & Co., Ltd. 109
Budenberg Gauge Co., Ltd. 7
Bullows, A., & Sons, Ltd. 127
Butcher, H., & Co. 125

C. & M. Engineering Co., Ltd. 98
Cape Asbestos Co., Ltd. 10
Carron Co. 60
Carter, B. & F., & Co., Ltd. 102
Clyde Crane & Booth, Ltd. 74
Clyde Crane & Engineering Co. 74
Cockburns, Ltd. 32
Colt Ventilation, Ltd. 3
Colvilles, Ltd. 30
Coventry Climax Engines, Ltd. 64
Cowlishaw, Walker & Co., Ltd. 98
Crane, Ltd. 65
Crofts (Engineers), Ltd. Cover i
Crompton Parkinson, Ltd. 96
Cross Manufacturing Co. (1938), Ltd. 24
Cull, W. B., & Sons, Ltd. 105

Dawson & Downie, Ltd. 48
Dorman Long 42
Drummond - Asquith (Sales), Ltd. 58
Dzus Fastener Europe, Ltd. 81

Edwards, L., & Co. (Engineers), Ltd. 47
Electrical Power Engineering Co. (B'ham), Ltd. 18
Electro-Dynamic Construction Co., Ltd. 59
Electronic Engineering 24
Elgar Machine Tool Co., Ltd. 27
English Steel Rolling Mills Corporation, Ltd. 40
Etchells, D., & Son, Ltd. 2
Evans, F. W., Ltd. 34

Fairfield Shipbuilding & Engineering Co., Ltd. 51
Farmer, L., & Sons. 125
Ferranti, Ltd. 31
Filton, Ltd. 49

PAGE

Firth, T., & Brown, J., Ltd. 55
Fischer Bearings Co., Ltd. 44
Fleming & Ferguson, Ltd. 98
Flexible Ducting, Ltd. 2
Foord, J., & Co. 125
Ford Motor Co., Ltd. 69
Fordsmith, H., Ltd. 38
Forster, T. S., & Sons, Ltd. 50
Fuller Horsey, Sons & Cassell 125

Gandy, Ltd. 85
General Electric Co., Ltd. 47
Girdlestone Pumps, Ltd. 115
Globe Pneumatic Engineering Co., Ltd. 36
Greening, N., & Sons, Ltd. 102
Griffiths, Gilbart, Lloyd & Co., Ltd. 4
Guest, Keen Iron & Steel Co., Ltd. 21

H.M.S.O. 121
Hadfields, Ltd. Cover ii
Hall & Hall, Ltd. 94
Hall, M., & Co., Ltd. 120
Hallamshire Steel Co., Ltd. 114
Harvey, G. A., & Co. (London), Ltd. 14
Herbert, A., Ltd. 106
Higgs Motors, Ltd. 19
Hill & Jackson (Springs), Ltd. 92
Hingley, N., & Sons (Netherton), Ltd. 61
Hobson, H. M., Ltd. 57
Hoffmann Manufacturing Co., Ltd. Cover iii
Holroyd, J., & Co., Ltd. 28
Hudswell Clarke & Co., Ltd. 102
Hunt & Moscrop, Ltd. 94
Hyde, R., Castings 23
Hydraulics & Pneumatics, Ltd. 91

Ilford, Ltd. 33
Imperial Chemical Industries, Ltd. 101
Imperial Chemical Industries, Ltd., Billingham Division 110
Ince Forge Co., Ltd. 18
International Combustion Products, Ltd. 12

PAGE

International Computers & Tabulators, Ltd. 71

Jellyman, S., Ltd. 21
Jenks Bros., Ltd. 80

Kautex, Ltd. Cover iii
Kay & Co. (Engineers), Ltd. 94
Kempe's Engineers Year-Book 121
Kenyon, W., & Sons, Ltd. 16
King, Geo. W., Ltd. 20

Lanarkshire Bolt, Ltd. 60
Lancaster & Tonge, Ltd. 115
Leeds & Bradford Boiler Co., Ltd. 62
Lewin Road Sweepers, Ltd. 7
Lockheed Precision Products, Ltd. 112
London Electric Firm, Ltd. 16
Lucas, J. (Hydraulic & Combustion Equipment), Ltd. 53
Lynch, M., & Son, Ltd. 105

MacLellan, P. & W., Ltd. 92
Markland Scowcroft, Ltd. 88
Marshall Fleming & Co., Ltd. 94
Maxseal Valves, Ltd. 38
Mechanical Equipments, Ltd. 81
Mersey Cable Works, Ltd. 83
Metropolitan - Vickers Electrical Co., Ltd. 41-Cover iv
Micanite & Insulators Co., Ltd. 18
Midgley & Sutcliffe, Ltd. 8
Mirrlees, Bickerton & Day, Ltd. 90
Mobil Oil Co., Ltd. 108
Monk, A., & Co., Ltd. 63
Morgan Refractories, Ltd. 13
Morris, H., Ltd. 128
Mountford, F. (B'ham), Ltd. 126

National Steel Foundry (1914), Ltd. 66
Neco Geared Motors, Ltd. 7
Newbury Diesel Co., Ltd. 98
Newton Sales Co., Ltd. 37
Nitralloy, Ltd. 124

PAGE

Norris Bros., Ltd. 38

Oakey, J., & Sons, Ltd. 115
Oberman, J. H., & Sons, Ltd. 106
Osborn, S., & Co., Ltd. 6

Parker, F., Ltd. 66
Parkinson, Sir Lindsay, & Co., Ltd. 25
Patent Lightning Crusher Co., Ltd. 105
Peckett & Sons, Ltd. 34
Peebles, Bruce, & Co., Ltd. 109
Peglers, Ltd. 81
Phœnix-Rheinrohr A.G. 110
Pinchin, Johnson & Co. 80
Pitman, Sir Isaac, & Sons, Ltd. 121
Pittam, J., & Co. 76
Plenty & Son, Ltd. 5
Pool, J. & F., Ltd. 82
Potter, F. W., & Soar, Ltd. 18
Power-Gas Corporation, Ltd. 9
Precision Rubbers, Ltd. 93
Price Machine Guards, Ltd. 106
Prodorite, Ltd. 29

Quasi-Arc, Ltd. 87

Ratcliffe, F. S. (Rochdale), Ltd. 15
Reynolds Tube Co., Ltd. 69
Rice & Co. (Leeds), Ltd. 102
Rotork Engineering Co., Ltd. 24

Salter, G., & Co., Ltd. 103
Saunders-Roe, Ltd. 84
Savery, T., Pumps, Ltd. 82
Schieldrop & Co., Ltd. 82
Scriven Machine Tools, Ltd. 24
Semtex, Ltd. 77
Shaw, J., & Sons (Salford), Ltd. 49
Simons, W., & Co., Ltd. 126
Slingsby, W., & Co., Ltd. 59
Smedley Bros., Ltd. 102
Smith & McLean, Ltd. 60
Smiths Industrial Instrument Division 45

PAGE

Spencer - Bonecourt - Clarkson, Ltd. 79
Standard Piston Ring & Engineering Co., Ltd. 37
Steels Engineering Installations, Ltd. 107
Stephenson, R., & Hawthorns, Ltd. 17
Sterling-Safway 97
Storey, T. (Engineers), Ltd. 114
Strachan & Henshaw, Ltd. 11
Sturtevant Engineering Co., Ltd. 23
Sulzer Bros. (London), Ltd. 116
Super Oil Seals and Gaskets, Ltd. 62

Taylor & Challen, Ltd. 65
Technical Applications, Ltd. 117
Telco, Ltd. 50
Thermal Elements 92
Thompson, J., Motor Pressings, Ltd. 75
Thornton, B., Ltd. 54
Tilghman's, Ltd. 75
Turbine Furnace Co., Ltd. 47

United Steel Companies, Ltd. 99

V.W. Co., Ltd. 27
Vickers - Armstrongs (Engineers), Ltd. 43
Vokes, Ltd. 39

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Ward, T. W., Ltd. 124
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TRIBUTE FROM ANTARCTICA . . .

T.A.E. Photograph

The Ross Sea Committee of the Trans-Antarctic Expedition has sent the photograph alongside and a report written by Mr. J. E. Hoffman, the drilling and explosives expert at Scott Base, of which the following is an extract —

"The Hydrovane '60' Compressor was used attached to one of the Ferguson tractors through the standard power take-off. A four inch flat belt was used for the main drive The main function of the compressor was to supply air to remove cuttings while drilling holes from five to twenty feet with a portable rotary diamond drill . . . . and in addition, air was used for conventional type percussion drills and spades.

The compressor was never a worry and always operated according to the maker's specifications. The average summer temperature in which they were used was between 15°F. and 20°F., and the only modification was a canvas cover to close off cooler during warm-up period. Oil recommended and supplied by B.P. was used throughout the 500 hours of operation and the compressor was in first-class order when the job was completed.

In conclusion, I can have nothing but praise for the Hydrovane '60' compressor and could recommend it for any future work under the very difficult conditions to which it was subjected."

(Signed) J. E. Hoffman.

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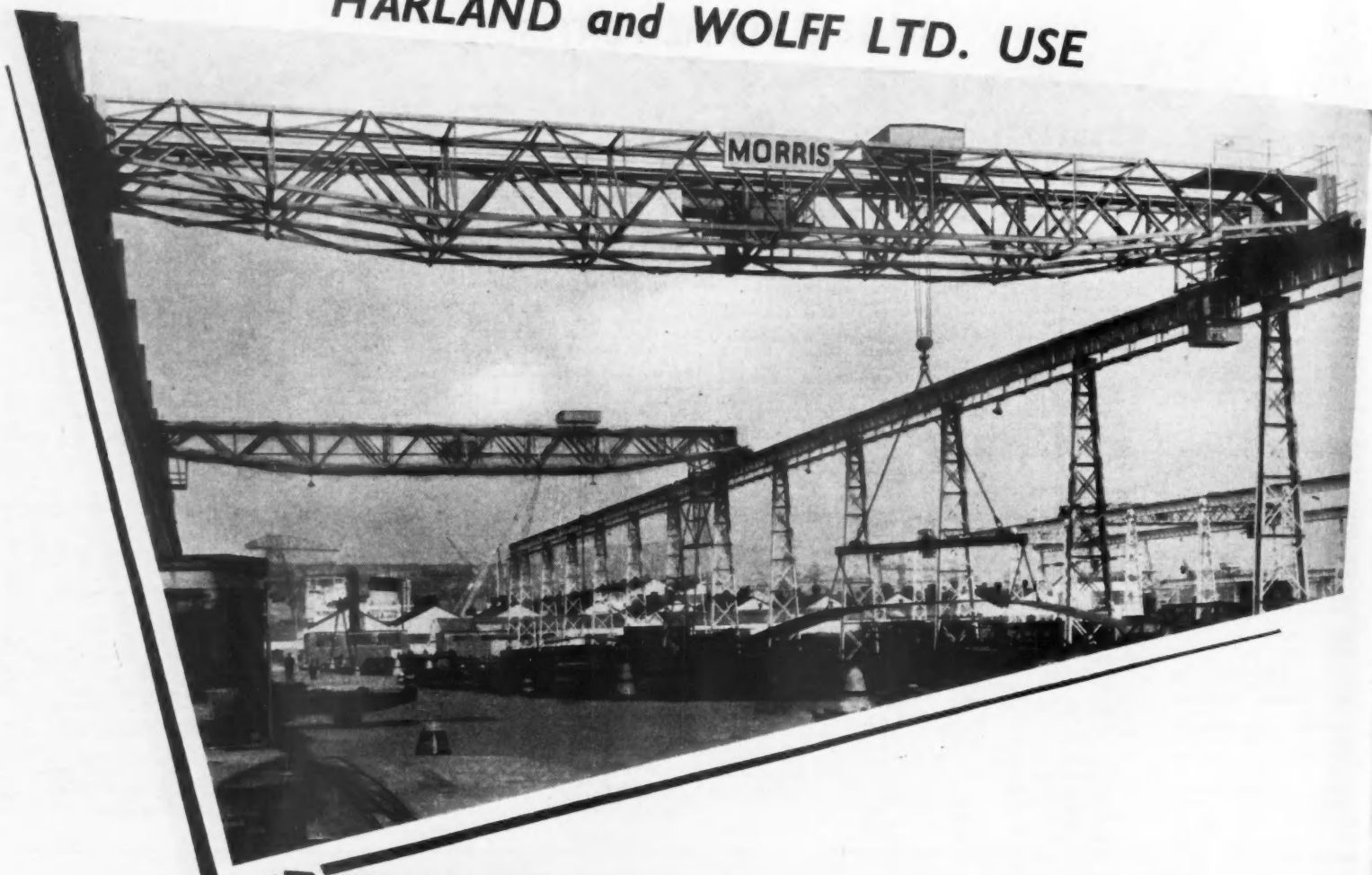

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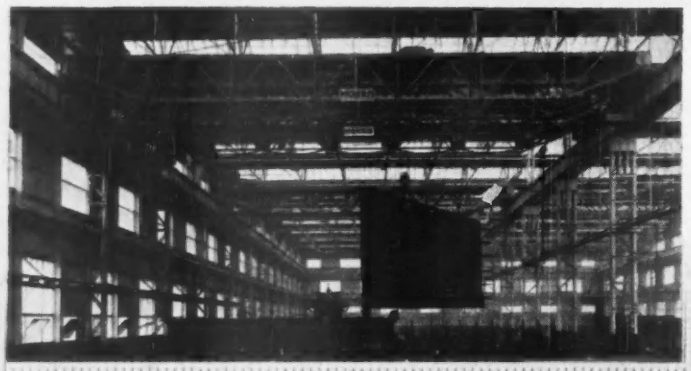

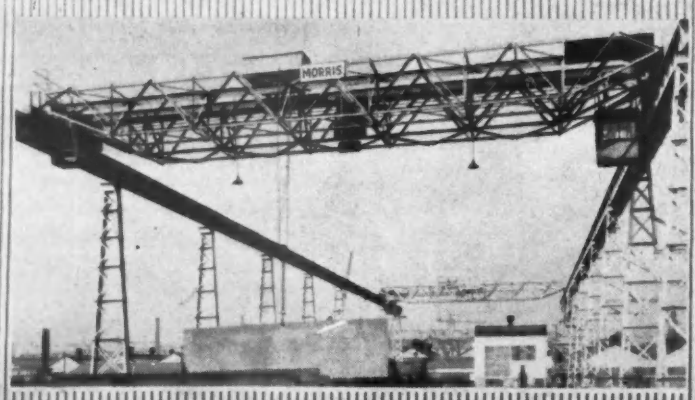

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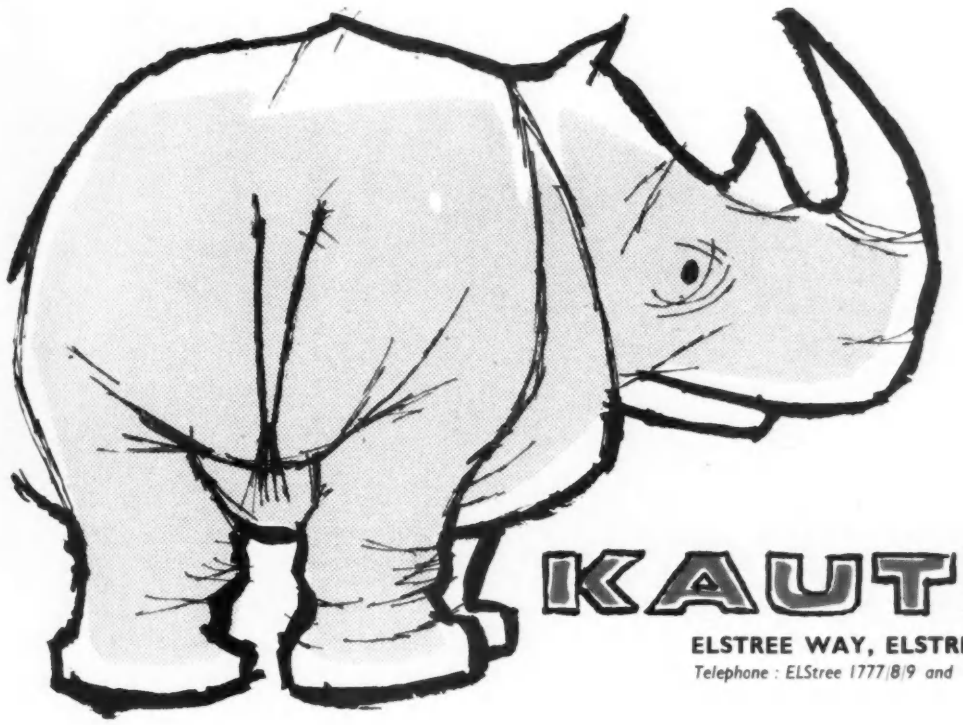

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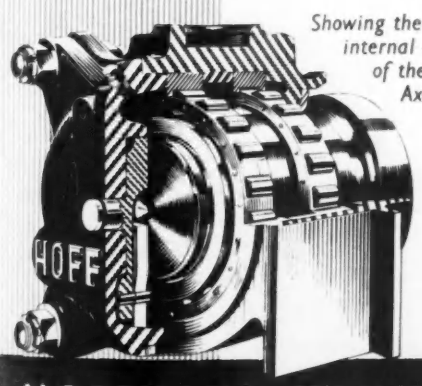

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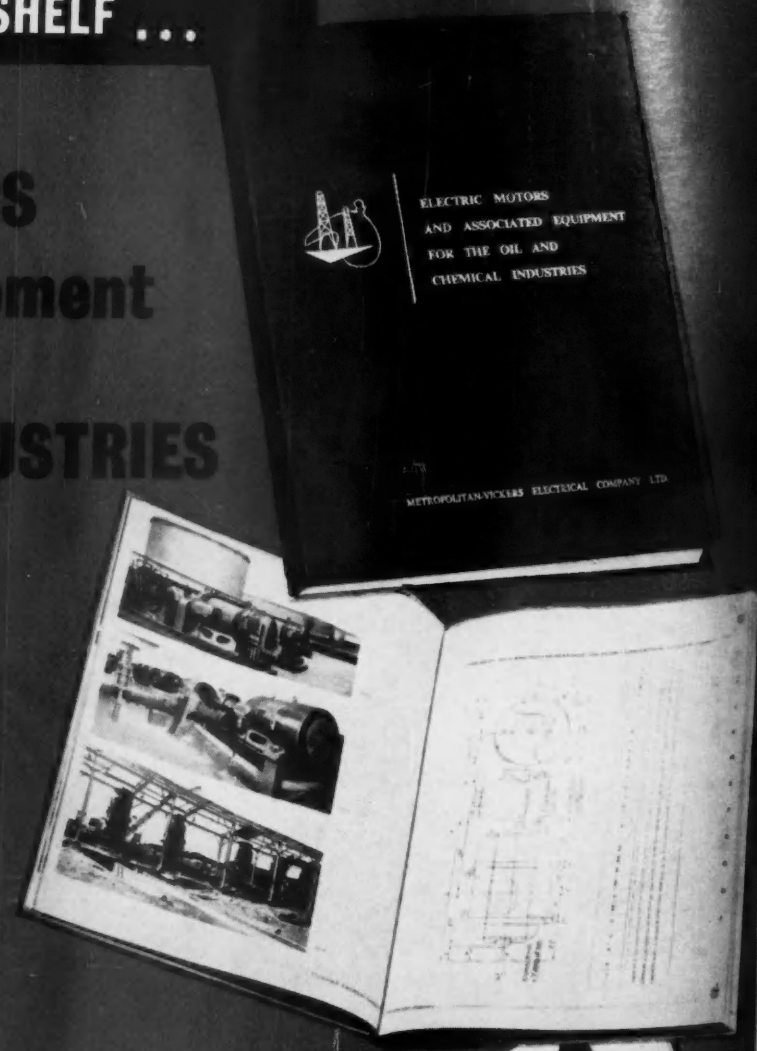

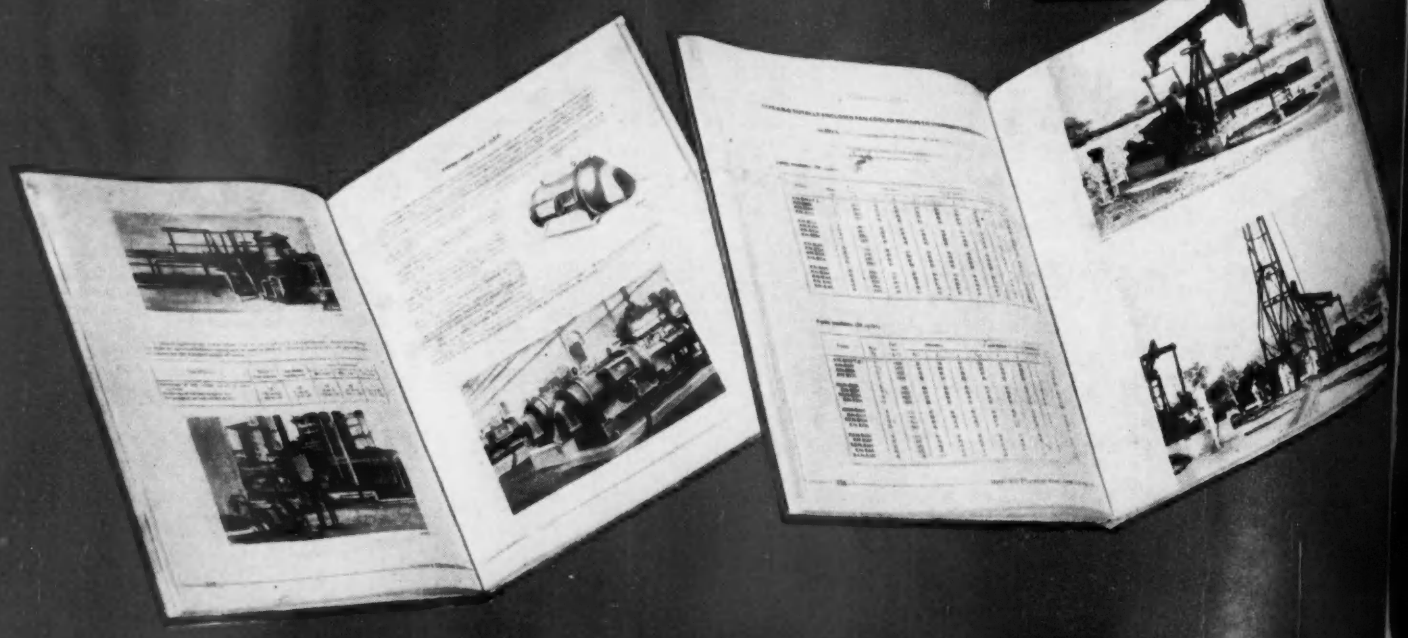

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